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INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

VOL. X NO. 8 AUGUST, 1960 RUPEES TWO

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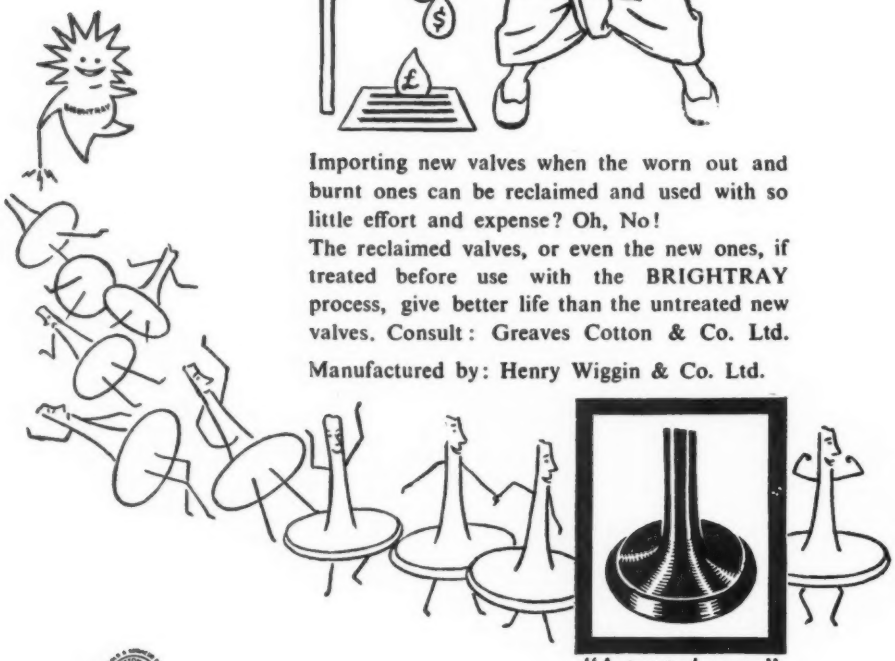

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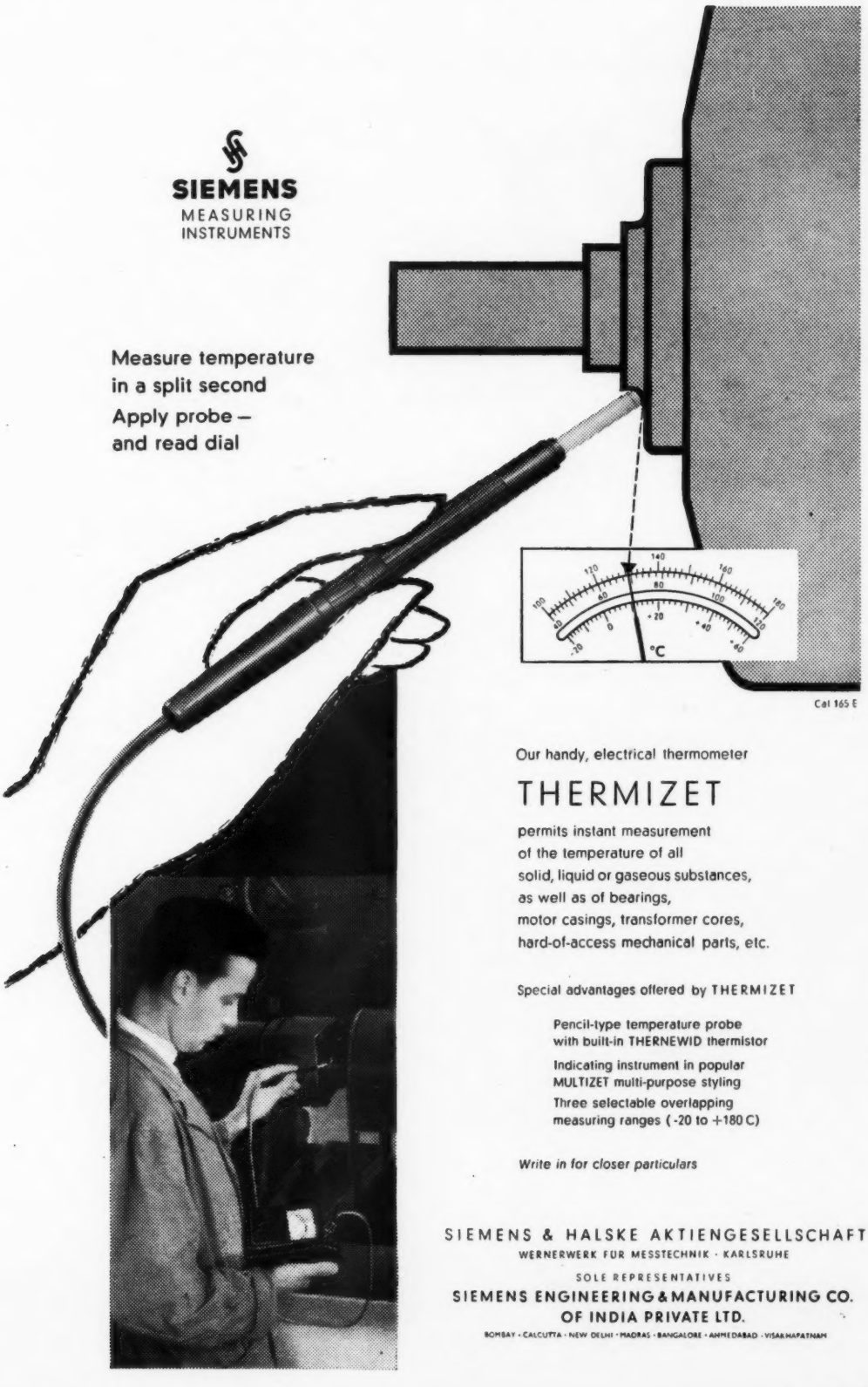

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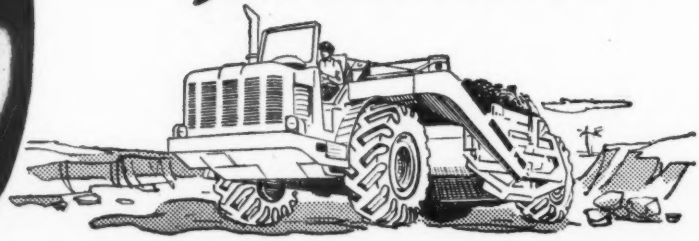

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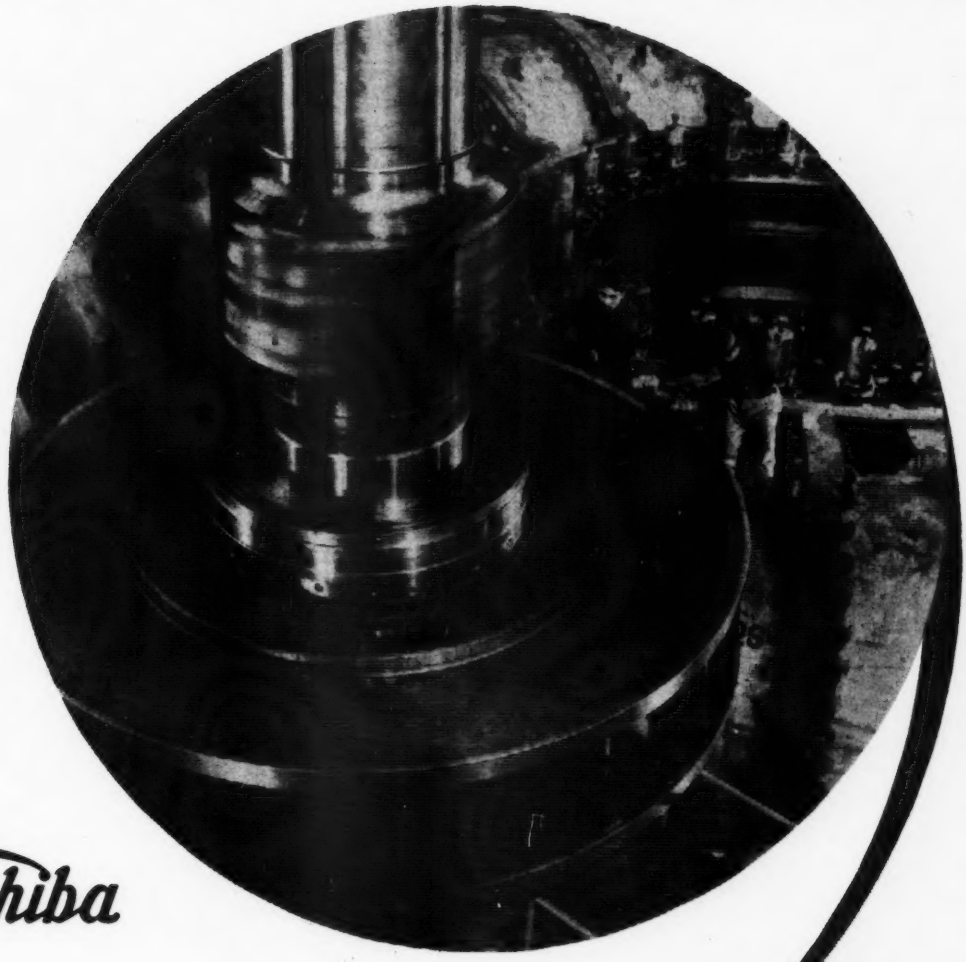

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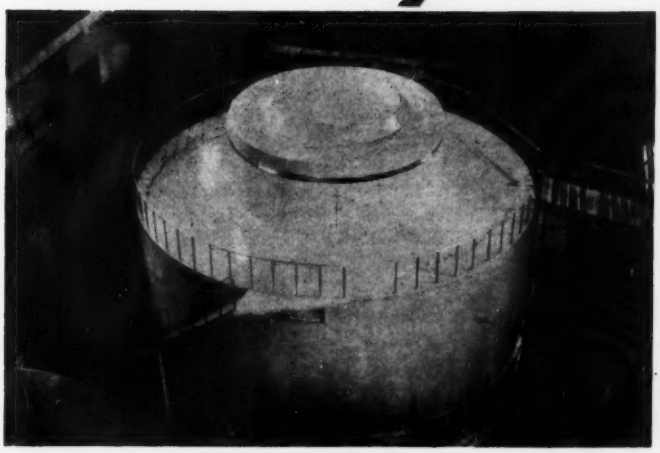

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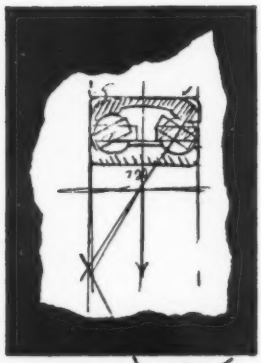
from this little sketch



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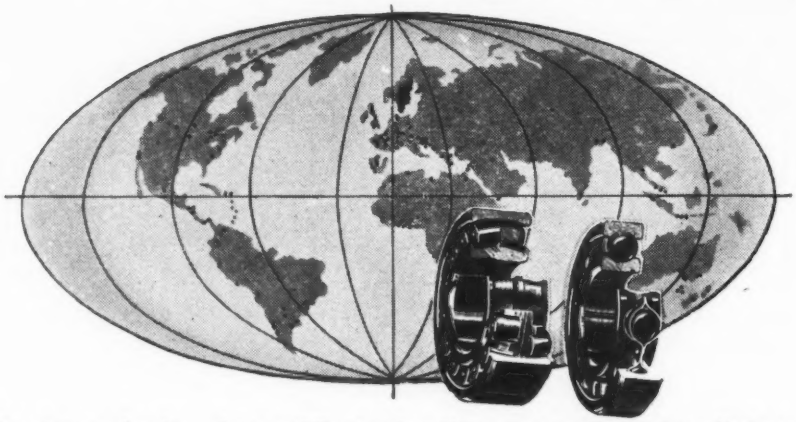
Sven Wingquist, founder of SKF and his epoch-making design...the self-aligning ball bearing —Sweden 1907



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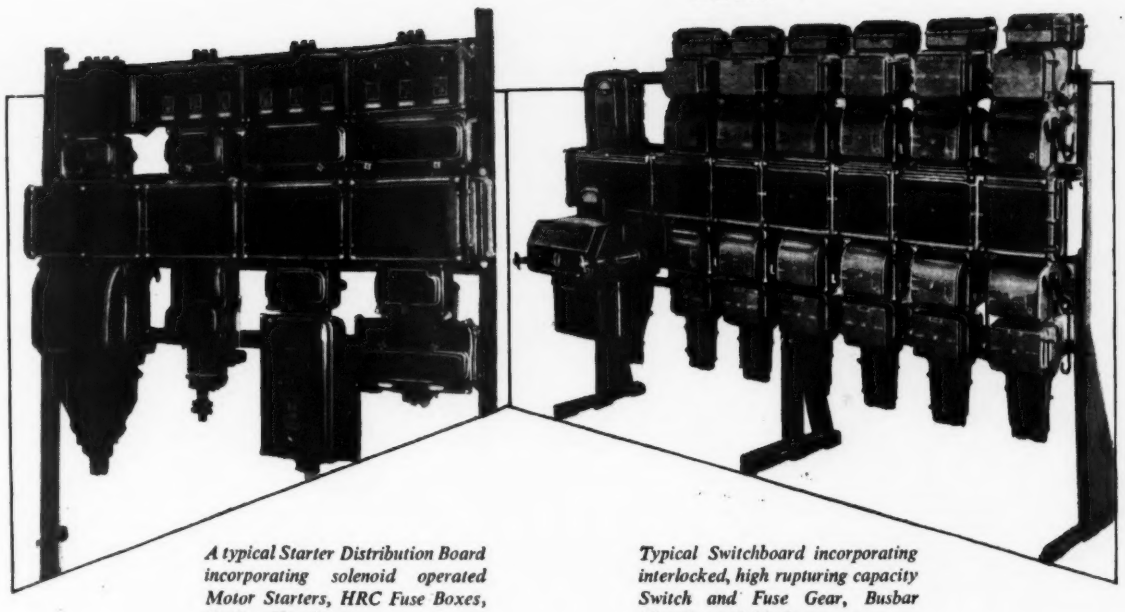

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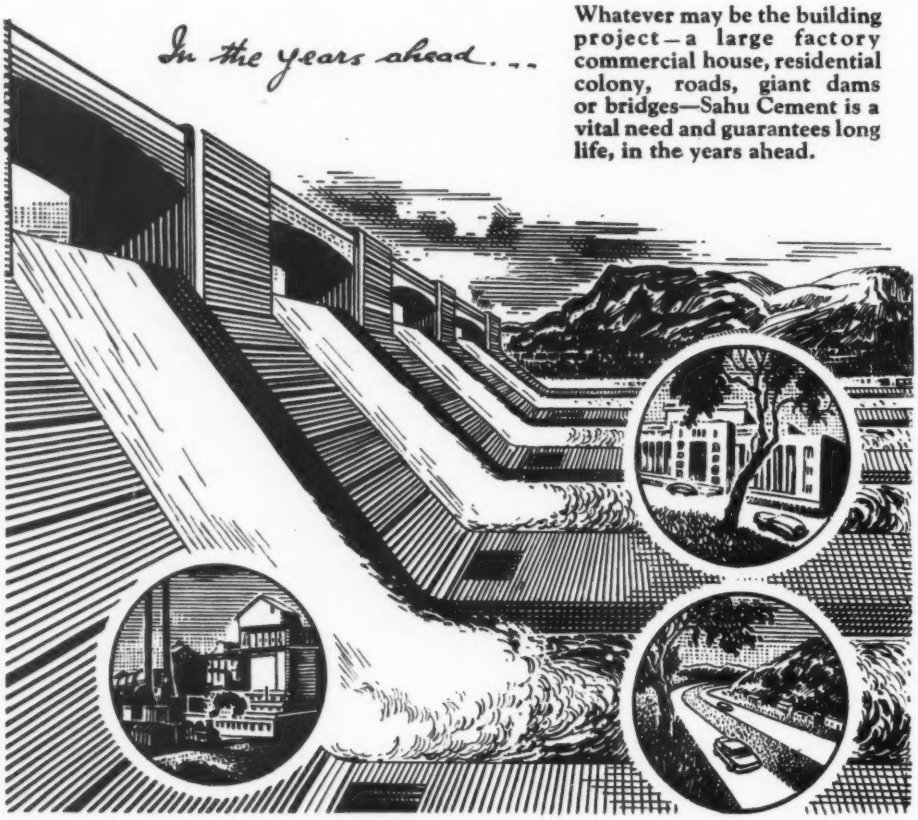

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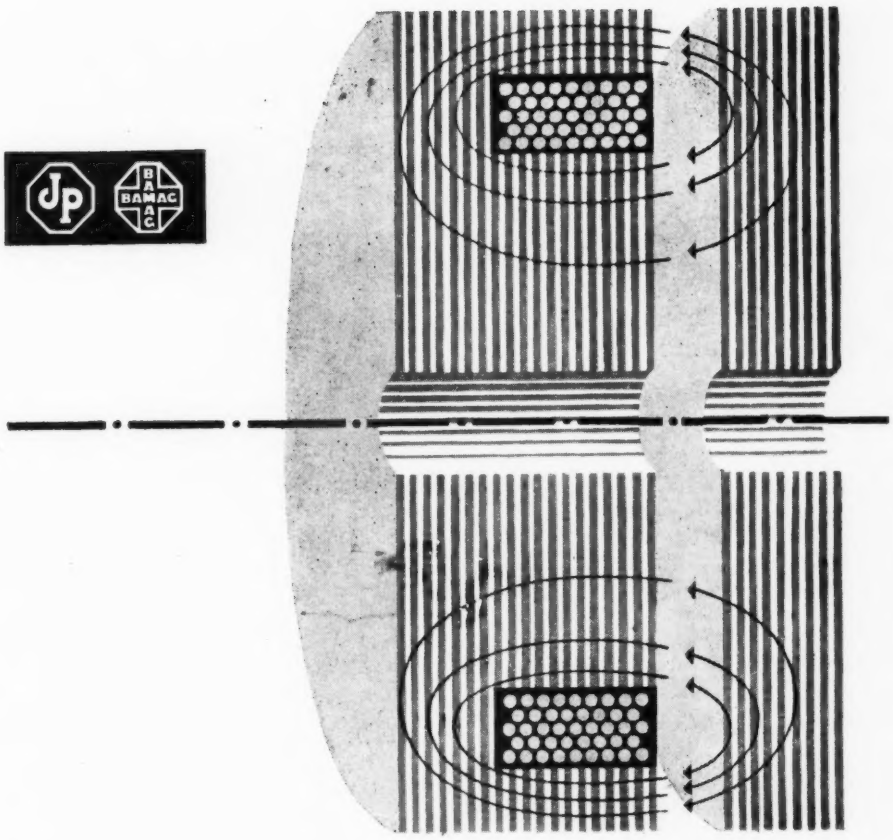

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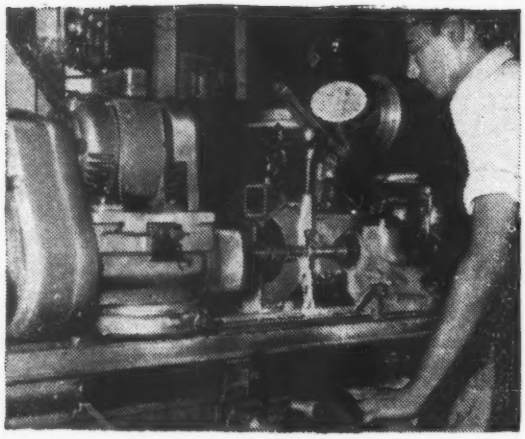

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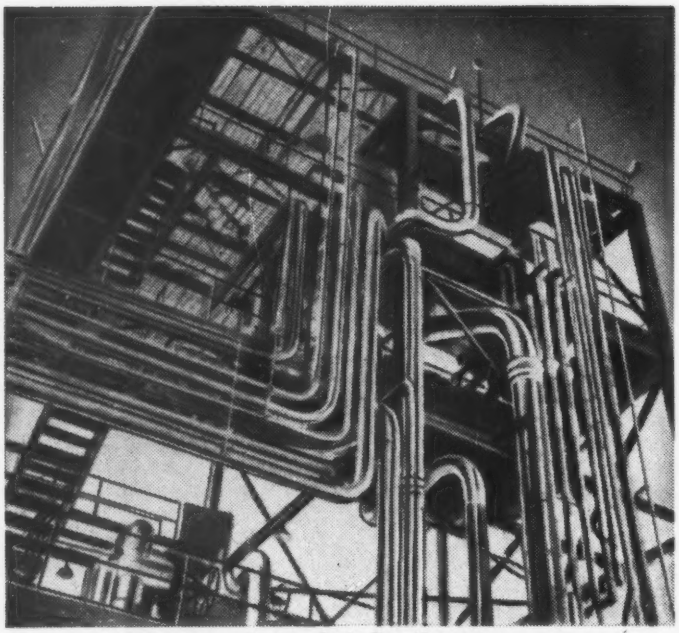

General view of pipework outside the turbine room at Trombay Thermal Power station

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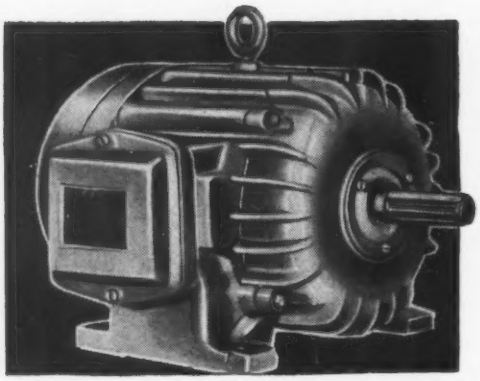

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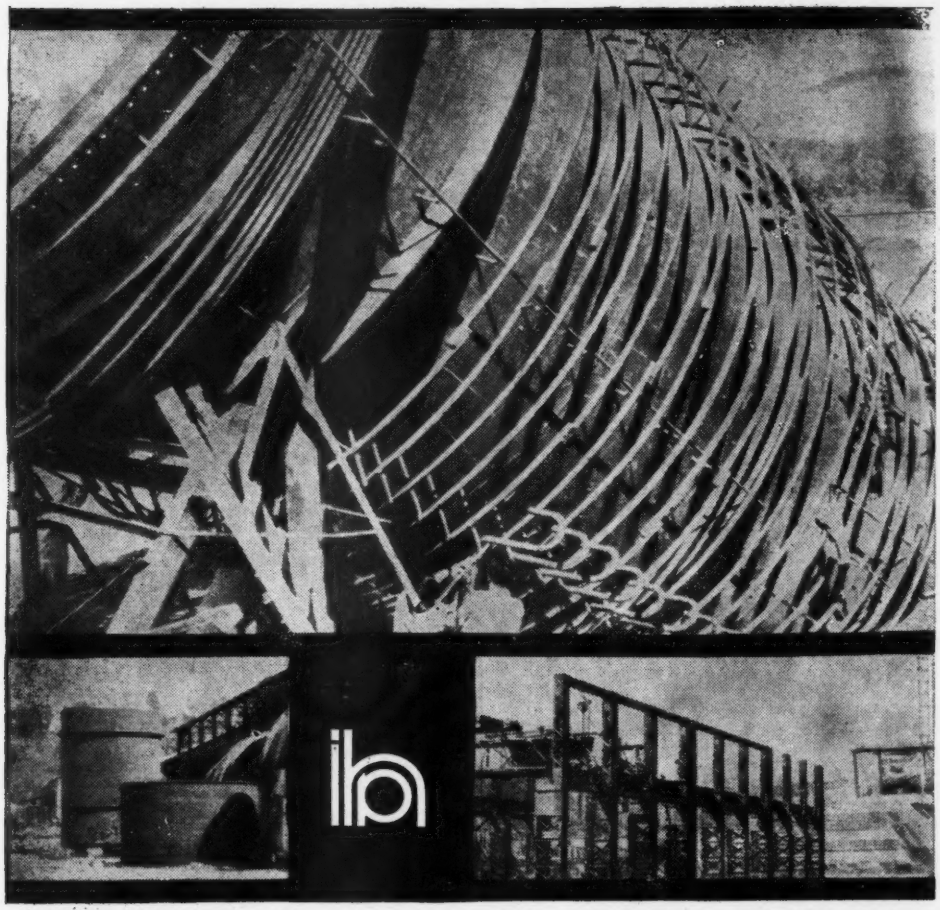

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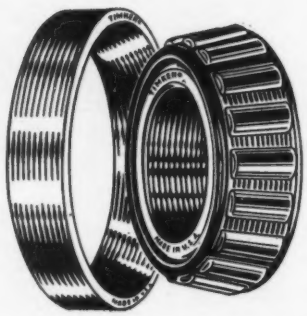

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A MONTHLY DEVOTED TO DEVELOPMENT OF POWER & WATER RESOURCES IN ASIA

Editor : K. K. Sinha

P. K. Menon : Mg. Editor

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The next issue will be a Special Number on Hydraulic Machines Symposium held at the Indian Institute of Science, Bangalore

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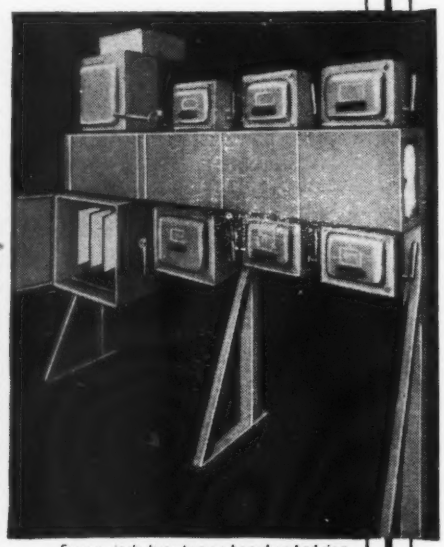

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AIC-227

Inland Waterways in the Soviet Union

By K. S. MISRA

The general policy in U.S.S.R is to use natural resources to the maximum extent in all spheres of development. Applying this to transport and communications, rivers, lakes, seas etc. find foremost place for utilisation (as natural waterways). By connecting them all with suitable link canals, it has been possible to make Moscow a "port of five seas" which is one of the biggest achievements of that country.

SOME STRIKING FEATURES

Some of the most striking features of this internal navigation are given below:—

(*i*) **Barges and Tankers:** as big as 12,000 tons carrying capacity (requiring 3.5 meters draught) can reach Moscow. Using 1200 h.p. pushers for these, it is possible to move as much as 10 tons per horse-power (see Table 1). The development of hydro-jet vessels is a big advance towards navigation in shallow waterways, because of significant reduction in draft requirements. The tugs, self-propelled vessels and passenger boats moved by hydro-jet propulsion, are of great interest, because these require less than one meter draft. Wooden barges are being replaced by steel barges.

Because of sea-like navigation conditions, in large reservoirs (formed by the dams), self-propelled vessels are increasing in number compared to pull or push towing through such reserviors. In other portions of the waterways, where dumb-craft is used, push towing is preferred to pull-towing, being far more economical than the latter.

(*ii*) **Link Canals and Locks:** The "Moscow" and "Volga Don" Link Canals exceed 100 kM in length each, and cross hundreds of feet high ridges to connect Moscow and Volga rivers and Volga and Don rivers. Longitudinal sections of link canals are shown below : (Fig. 1, 2 & 3)

(*iii*) **Locks:** The maximum sizes of locks (to negotiate level differences between different parts of link cannals and in moving across dams in the rivers) are of 300 meters lenth, 30 meters width and 5.5 meters minimum draught. Inspite of such big sizes and large difference in water levels, a complete cycle of "lock-operation" may not usually exceed 20 to 30 minutes.

These locks are electrically operated. To maintain highest pitch of efficiency, the entire movement and navigational operations are centrally controlled by "Dispatcher", system, which co-ordinates all sectons of the organisation connected with the movement, loading and unloading. All dispatcher offices are inter-connected by service telephones (as distinct from public telephones), teleprinter lines and radio-telephones.

(*iv*) **Ports:** There are dozens of inland ports, each of which handles millions of tons of cargo every year. The point of main-interest in them is the equipment. For cargo handling. It is all standardised and consists

Table I

STATEMENT OF CARGO-TONNAGE MOVED PER HORSE-POWER OF ENGINE

(1) Self-Propelled Vessels

SN.	*Speed (loaded).*	*Horse Power.*	*Tonnage.*	*Ton / HP.*	*Remarkes regarding Engines.*	
1.	12 kM per hour	150	60	0.4	Hydro-jet	Draught 0.77 meters.
2.	14.5 ,,	150	150	1	Screw prop	
3.	13.5 ,,	2×150=300	600	2	Twin screw	
4.	17 ,,	2×400=800	2000	2.5	Twin screw	"The Bolshaia Volga"
5.	18 ,,	2×500=1000	3300 (Oil)	3.3	Twin screw	Draught 3.5 meters
		(2) Tugs and Pushers				
1.	5	150	2×200=400	2.7	Hydro-jet	Draught 0.4 meters
2.	12	2×300=600	2×2850=5700 (The normal flotilla).	9.5	Twin screw	Average of 10 tons per horse power
3.	12	2×600=1200	12000 (The normal flotilla.	10	Twin screw	"ZELENO-DOLSK". Draught 2.22 meters.

Note : On an average, it can be seen that about 7 tons can be moved per h.p., at a speed of about 12 to 13 k.m. per hour.

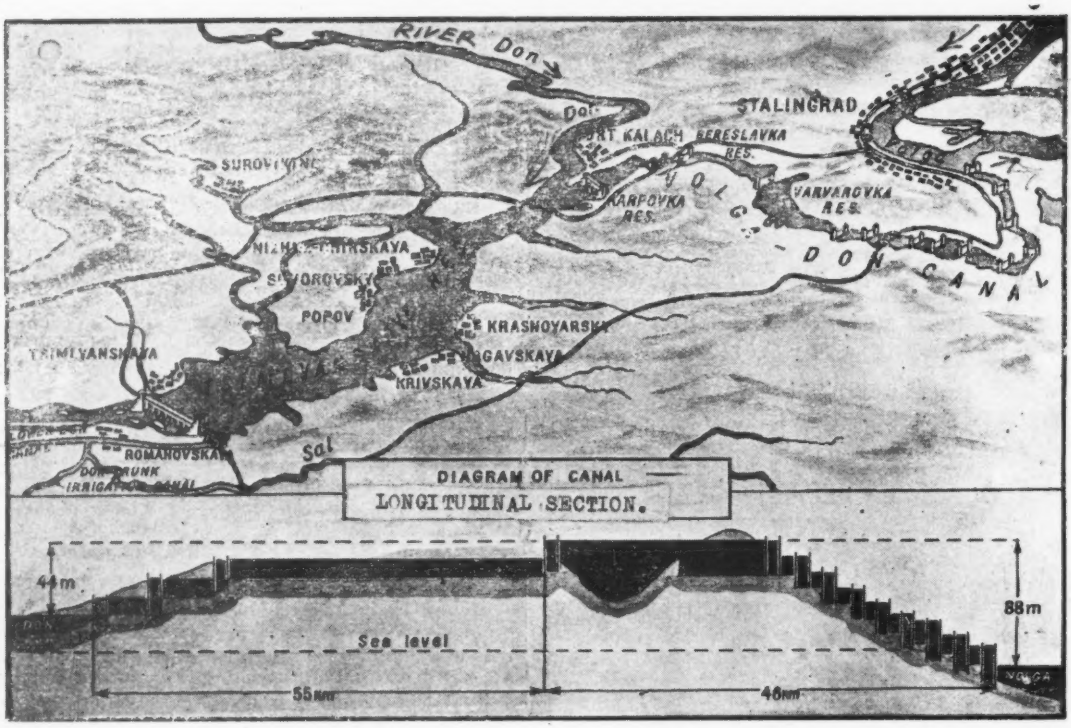


Fig. 1: Volga-Don Canal between rivers Volga and Don

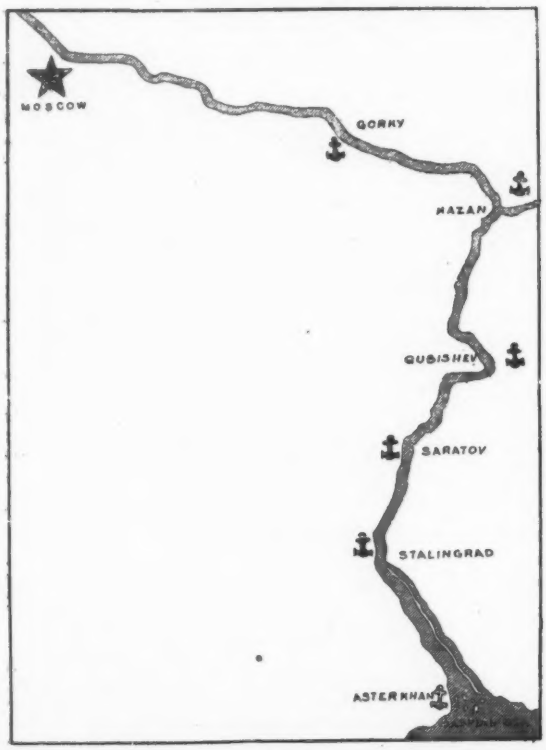


Fig. 2

of cranes 2 to 10 tons capacity, exclusive of floating cranes. [Table 2].

Table 2

EQUIPMENT FOR CARGO-HANDLING IN MOSCOW SOUTH PORT

Type of equipment	*Number*	*Capacity (t)*	*Radius (m)*	*Power H.P.*
Portal cranes.	4	3	22	—
	22	5	25	—
	2	10	25	—
Floating cranes.	8	3	,,	—
	2	15	,,	—
Fork lift trucks.	6	3	—	—
	12	5	—	—
Electric trollies.	50	1.5-5	—	—
Harbour tugs.	5	—	—	300

Note:—(1) This port handles nearly six million tons per working season (of about seven months).

(2) Operation of cranes by "remote control" is under trial here.

Conveyor belts have gone out of use almost completely. Movement inside the yards is entirely mechanical using fork-lift-trucks and electric trollies.

(*v*) **River Conservency :** Regarding river-conservency, the policy is to ultimately canalise the entire length of the rivers. Even at present, about half the

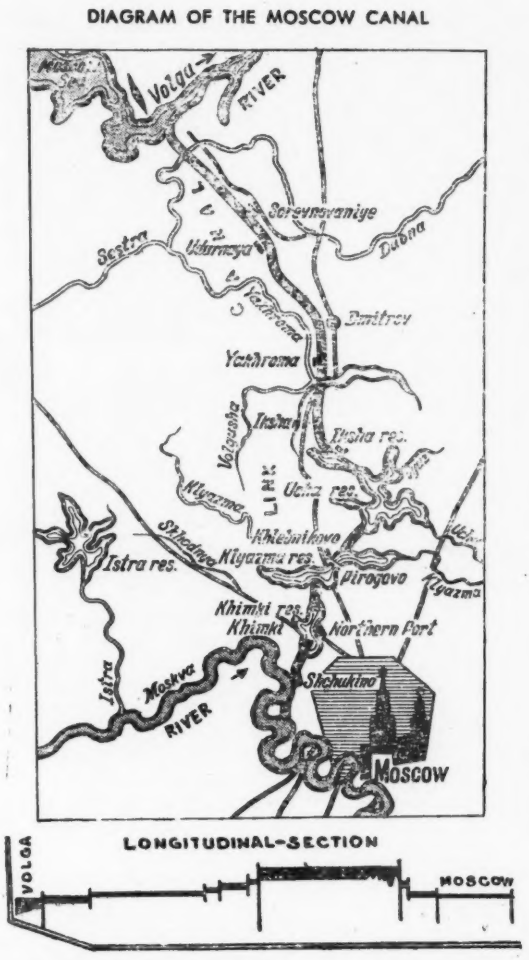


Fig. 3: Longitudinal Section of Link Canal between rivers Volga and Moscow

total length of the Volga river which is 3000 kM long is covered by reservoirs, some of which exceed 300 miles in length (see long section of Volga, Fig. 4).

Although the reservoirs so created eliminate the problem of maintenance of minimum draught for vessels, another difficulty has arisen i.e. waves of reservoirs (hundreds of miles long) create sea-like conditions for navigation as mentioned above. The old type of craft i.e. barges with push and pull tugs find it difficult to navigate through these lakes. This has resulted in an increase of self-propelled vessels in such reaches.

In portions which have yet to be canalised, "Suction" dredgers are mostly employed, of capacity varying from 300 to 600 cubic meters per hour (of solid material). Success of "draught maintenance" depends mainly on the technique of disposal of dredged material rather than on the quantity dredged. The dredged material is so placed that not only does it stay on during spring floods but, after the floods pass away, it develops and promotes "velocity patterns" which regenerate the deep channel by scouring away the silt brought down by the floods.

Thus, in river conservency, the cost of dredging operations has been reduced. What is of far-greater importance, is the fact that by above mentioned procedure during the recent fifteen years period taking navigable rivers as a whole, average channel depths have increased by 28 per cent and channel widths by 9 per cent.

Bank Protection

"Bank protection works" are kept in general two meter high (vertically) for withstanding forces of the breaking stern waves. The toe of these "bank protection works" consists of timber piles in case of Moscow Canal, while in all other cases it is rubble stone.

NAVIGATION IN MULTI-PURPOSE PROJECTS

In majority of cases "Inland Water Transport" forms part of multipurpose schemes comprising of Hydro Power Generation, Navigation, Flood Moderation and in some cases Irrigation also. No allocations are made of the "Capital" invested between the above mentioned four components of the projects. Thus no accounts are kept of interest charges on the capital investment. Also the cost of annual maintanance of the waterways and installations is charged

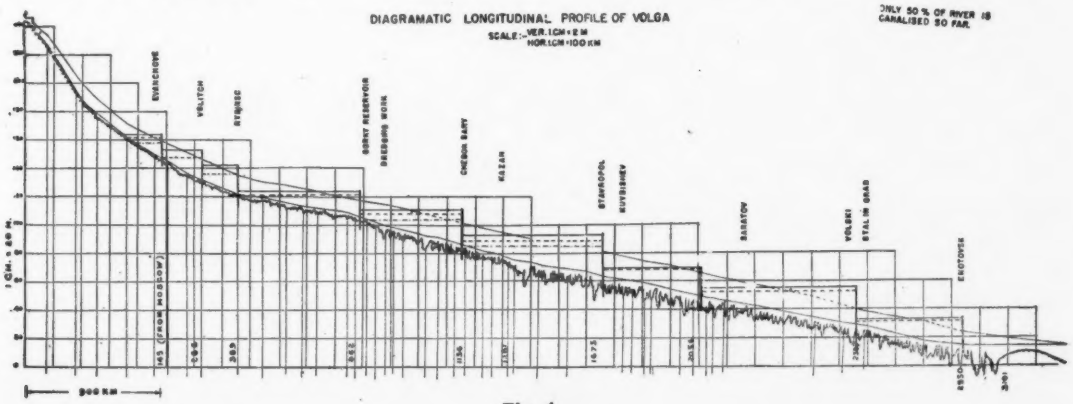


Fig. 4

to General Funds of the Government and is, therefore, excluded from the "Annual Expenditure of Operation of the Inland Water Transport".

Further, the rates and fares are based on cost of river transport in such a way that in general there is no profit or loss (see Table II & graph. Fig. 3.)

PRINCIPLES OF TRANSPORT PLANNING

Railways have not been allowed to compete with the water-ways and carry the cargo which was possible to go by navigation.

This is so, because railways and roadways could be constructed at all possible places, whereas navigation could be done only where natural resources like rivers, lakes and seas existed.

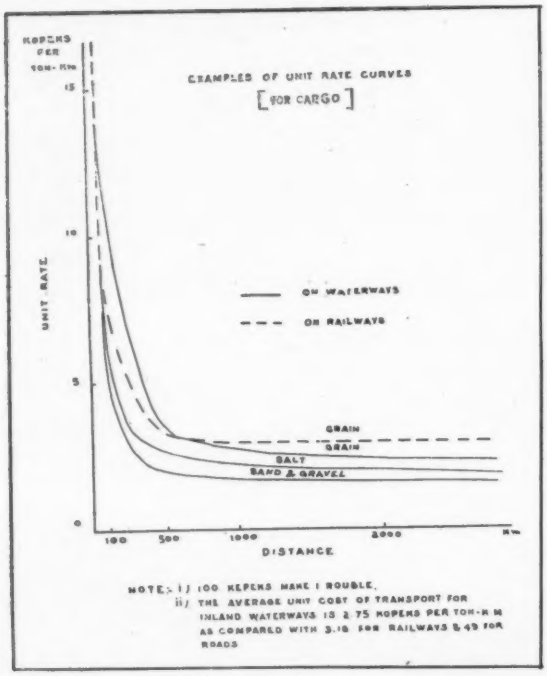
The State transport is planned by the Gosplan (state planning organisation for transport). Annual traffic is divided between railways and inland waterways and other modes of transport like pipe lines. Roadways feed either of them instead of competing with them.

Table 3

PASSENGER FARES

Distance (Km).	*Days*	*de-luxe*	*1st class.*	*2nd class*	*3rd class*		*4th class*
					berth	*no. berth*	
121	½	107.70	77.10	61.80	31.30	25.60	15.20
556	2	194.30	153.50	116.70	69.90	58.70	36.20
1,032	3	276.70	215.50	164.90	96.40	79.50	48.90
1,499	4	345.60	264.80	204.10	114.50	93.40	57.50
2,018	5½	422.50	320.50	248.10	133.50	110.60	68.40
2,502	6½	493.30	370.90	288.90	151.70	125.60	77.60
3,035	7½	564.70	421.90	329.70	166.60	140.50	87.00

Fig. 3.



APPLICABILITY TO INDIA

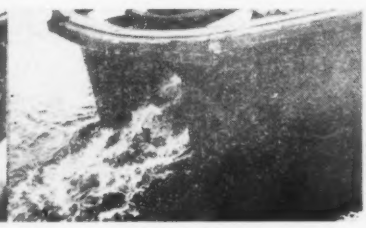
Planning and co-ordination of transport (by water, rail and road) is necessary to avoid unhealthy competition. These three modes of transport should be supplementary to one another to ensure that the best use will be made of all available resources of the country. The method of planning to this end, in the Soviet Union is an example which could be followed with benefit. Inspite of highly developed railways and the fact that the rivers are ice-bound for five months in the year, the Soviet Government has directed its efforts to increased utilisation of waterways for transport purposes wherever possible.

Like the Volga, Don, Amur and other large rivers in the Soviet Union and the Danube in Europe, India has large rivers such as the Brahmaputra, Ganga, Mahanadi, Godavari, Krishna and Nermada. Except for the Brahmaputra, navigation on these rivers is developed only to a relatively small extent.

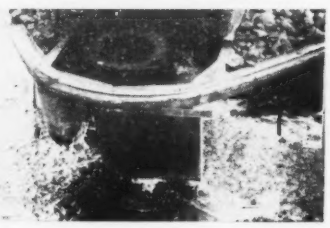
Large reservoirs are being constructed and planned for future on the rivers and their tributaries in our country as part of multi-purpose projects. This will result in reduction of flood discharges and increase of the minimum flow in the dry season, making the river conditions more favourable to navigation. Construction of numerous irrigation canals, of large dimensions, has been included in our Five Year Plans.

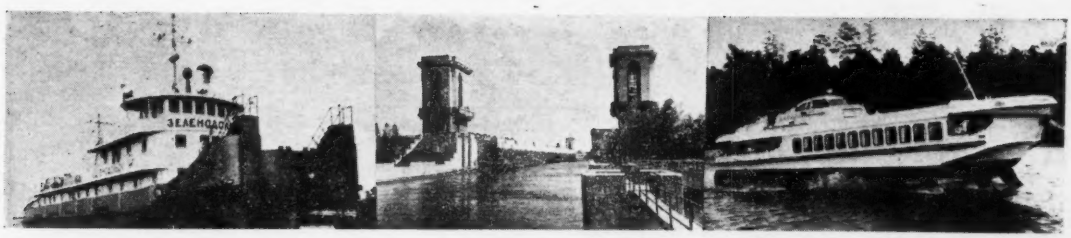
Stern of hydro-jet propelled vessel

Hydro-jet operating ahead



Hydro-jet operating astern





T.22. Twin-screw pusher (1,200 hp) "Zelnodolsk"

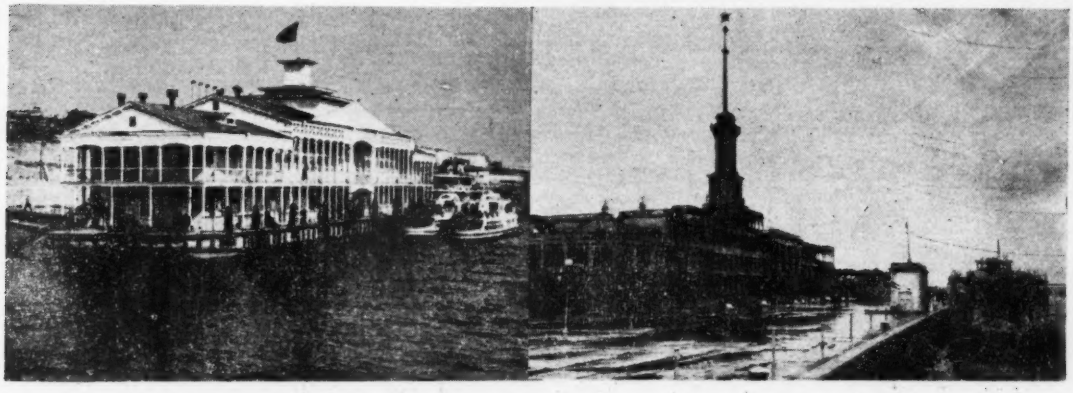
Lock on Moscow Canal

PA.7. "Raketa"-type hydrofoil craft (66 passengers, 900 hp, speed 60 km/h)

Navigation could be provided in the same to maximum possible extent, like the irrigation-cum-navigation canals of U.S.S.R. and Hungary viz. The Great Karakum Canal of Eastern Russia (under construction) and the Tsiza-Lok canal of great Hungarian Plains (recently constructed).

Dumb barges between 150 and 600 tons carrying capacity.
Tugs and pushers between 100 and 600 h.p.

Self-propelled craft between 60 and 600 tons carrying capacity.



Floating passenger terminal on concrete pontoon

Main passenger terminal

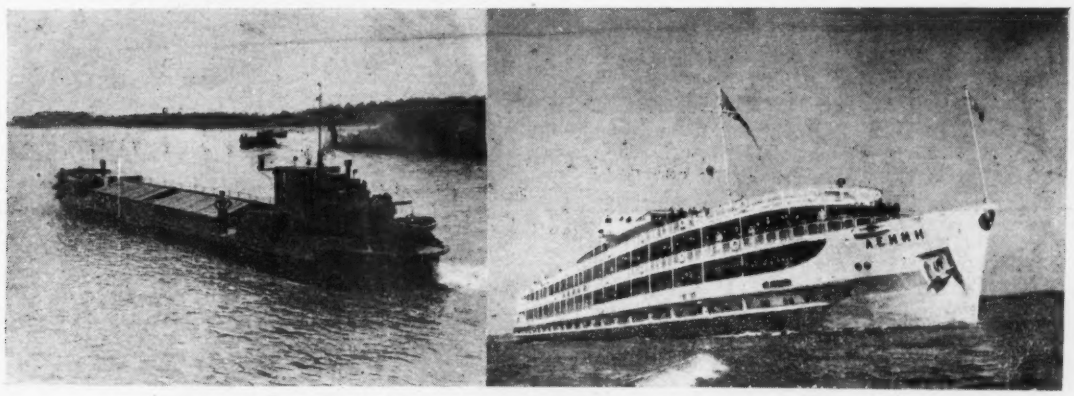
Since the depths of water-ways in India are rather limited, the larger craft used in the Soviet Union would not be suitable for Indian conditions. Some of the constructional features of these larger vessels may, however, be of interest. Of the smaller craft, the following types may, with minor modifications, be suitable for conditions in India:

SHALLOW DRAUGHT NAVIGATION

For shallow draught navigation, it has been seen that the system of hydro-jet propulsion is well developed in the Soviet Union. This system does not compare in efficiency with screw propulsion, but in certain very shallow sections it may prove to be the most suitable type.

Hydro-jet vessel

Lenin Ship 1959



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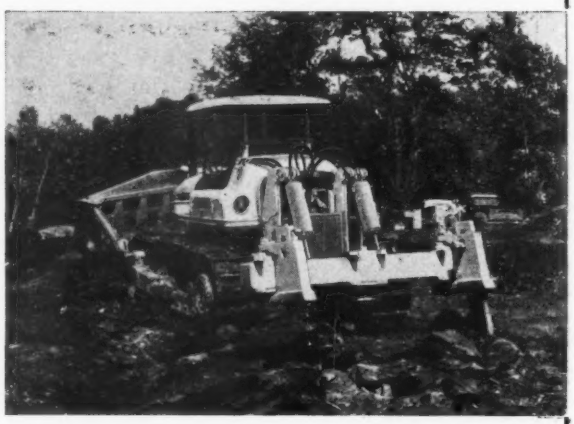

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EG/87

Balu Chaung Project, Burma

By MAUNG AYE

The hydro-electric power development in the Union of Burma received foremost consideration of the Government immediately after the attainment of the country's independence. Since the commencement of hydro-electric surveys in 1948, twenty-two potential water power sites in various parts of the country were investigated and designs for seven of these have been carried out.

The Balu Chaung Project is the first hydro-electric project selected by the Government of the Union of Burma for implementation. It has the ultimate installed plant capacity of 240,000 kW with annual energy output of 1,700 million kilowatt hours. It is situated approximately 70 miles east of Pyinmana which is about halfway between Rangoon and Mandalay. These two cities will be the terminal points of high voltage transmission of poser from the Balu Chaung, which will also supply on route importnt parts of Central Burma and the Shan States. The project will thus provide the nucleus for a national grid system supplying cheaper and more abundant power for domestic requirements and industrial development of the country.

This article gives an outline of the principal features of the project and of the civil engineering, hydraulic and electrical works involved in the first-stage development for an installation of 84,000 kW plant. It also gives a brief account of the extensive road construction programme associated with the development of the project.

Headwaters of the Balu Chaung enter the Inle Lake which lies at an elevation of about 3,000 feet on the plateau of the Shan States in the middle-east part of the Union of Burma. The Inle Lake feeds the lower Balu Chaung; it provides natural storage and regulation of flow in the stream below. The lower Balu Chaung flows gently from Inle Lake to Loikaw, the capital of Kayah State, the actual drop in this course of about 60 miles being only 150 feet. From seven miles below Loikaw, it forms many cascades and falls, the total drop in level within a distance of about 12 miles up to its confluence with the Nam Pawn (a tributary of the Salween) being about 2,200 feet.

These waterfalls occur in three defined groups: (1) upper series of falls with an aggregate drop of 260 feet in about a 5-mile course. (2) middle falls with a total drop of 1,450 feet in about a 4 mile course and (3) the last series of falls with a drop of about 400 feet in the remaining 3 mile course of the river.

The first organised hydro-electric survey of the site was conducted by the Chief Engineer (Hydel) of the Electricity Supply Board in June 1953. The upper series of the falls were well-known in the area but it was only during this survey that the location and topography of the concentrated series of the middle 1,450 feet falls, now known as Lawpita Falls, were established for the first time. These falls were then inaccessible.

For hydro-electric power development, it is planned to construct three power stations in series, one for each group of falls, with the waterways of head and tail races connected from one station to the next one. The flow of water from the Inle Lake will also be further regulated by constructing a reservoir for additional storage near Mobye, at about 19 miles upstream of Loikaw. By this regulation, the present dry-weather flow of 380 cusecs. (minimum) to 450 cusecs. (in normal year) will be increased to 1,200 cusecs. At present, the mean annual flow in the Balu Chaung is about 1,800 cusecs. with seasonal variation from 700 cusecs. (average) during dry season to 2900 cusecs. (average) in the rainy season. The maximum flood flow recorded is 14,000 cusecs.

STAGES OF DEVELOPMENT

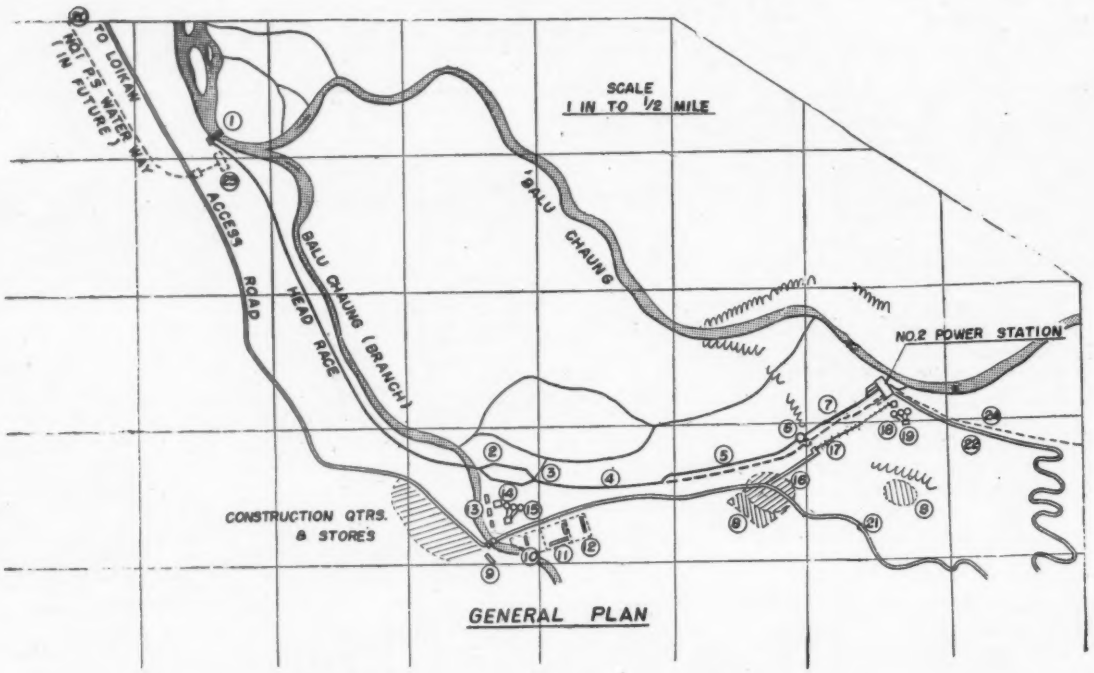
Power potential of the Balu Chaung at these three sites and the proposed stages of development are given below:—

Power Potential and Development Plan

Stages of Development	*Power Plant No.* / *Falls*	*No. 1* *1st Group*	*No. 2* *2nd Group*	*No. 3* *3rd Group*	*Total*
Gross Head (Ft.)		260	1,450	400	2,110
Net Head for Max. Discharge.....(Ft)					
1st Stage		244	1,395	377	1,991
2nd Stage			1,390		1,986
1st Stage Development[1]					
(1) Max. Discharge (with Pondage regulation) (cu. secs)		—	840	—	840
(2) Plant Capacity (kW)		—	84,000	—	84,000
(3) Annual energy output					
Firm (Million kWh)		—	340	—	340
Secondary (" ")		—	290	—	290
2nd Stage Development[2]					
(1) Max. Discharge (cu. secs.)		—	1,680	—	1,680
(2) Plant Capacity (kW)		—	168,000	—	168,000
(3) Annual energy output (M. kWh)		—	1,190	—	1,190
Ultimate Development[3]					
(1) Max. Discharge (cu secs).		1,500	1,680	1,800	—
(2) Plant Capacity (kW)		24,000	168,000	48,000	240,000
(3) Annual energy output. (M kWh)		180	1,190	330	1,700

[1] Before Mobye Reservoir Regulation

[2] & 3 With Mobye Reservoir Regulation



KEY NOTE :

No. 2. Power Station

1. **Intake & intake weir**
2. **Pondage**
3. **Spillway**
4. **Low pressure concrete conduit**
5. **Low pressure pipe line**
6. **Surge tank**
7. **Penstock**
8. **Permanent residential quarters**

Construction Facilities

9. **1500 kW diesel power plant**
10. **Motor pool**
11. **Repair shop**
12. **Saw Mill**
13. **Cement Godown**
14. **Mixing plant, 37.5 CY/H**
15. **Crushing plant, 90 T/H**
16. **Office & Quarters**
17. **Rop haulage, 15 T.**
18. **Mixing plant, 25 CY/H**
19. **Crushing plant, 45 T/H**
20. **No. 1. Quarry**
21. **No. 2. „**
22. **No. 3. „**

FUTURE PLAN

23. **No. 1. Power Station**
24. **No. 3. „ „ Waterway (Tunnel)**

ENGINEERING ORGANIZATION

The implementation of Balu Chaung Project is carried out by the Electricity Supply Board. The Planning, organization and technical control of the project are vested in the Chief Engineer (Hydel) who controls the entire works through the Chief Project Officer and the Divisional Engineers. The Transmission Lines and Sub-stations equipment are placed in charge of the Chief Engineer (Electrical & Mechanical).

Messrs. Nippon Koei Kabushiki Kaisha, a firm of Consulting Engineers of Tokyo, furnish the engineering services for the design and supervision of construction of the project under the leadership of Mr. Yutaka Kubota, the President of this firm of engineers. Messrs. Kajima Construction Co., also of Tokyo, supply the technical personnel required for the construction of civil engineering works. Local engineering personnel, artisans and labour are utilized to the fullest extent available in all the phases of the project. The organization has complete supporting sections consisting of Stores, Transportation and Cost Accounting Sections, and for Medical, Welfare and Security.

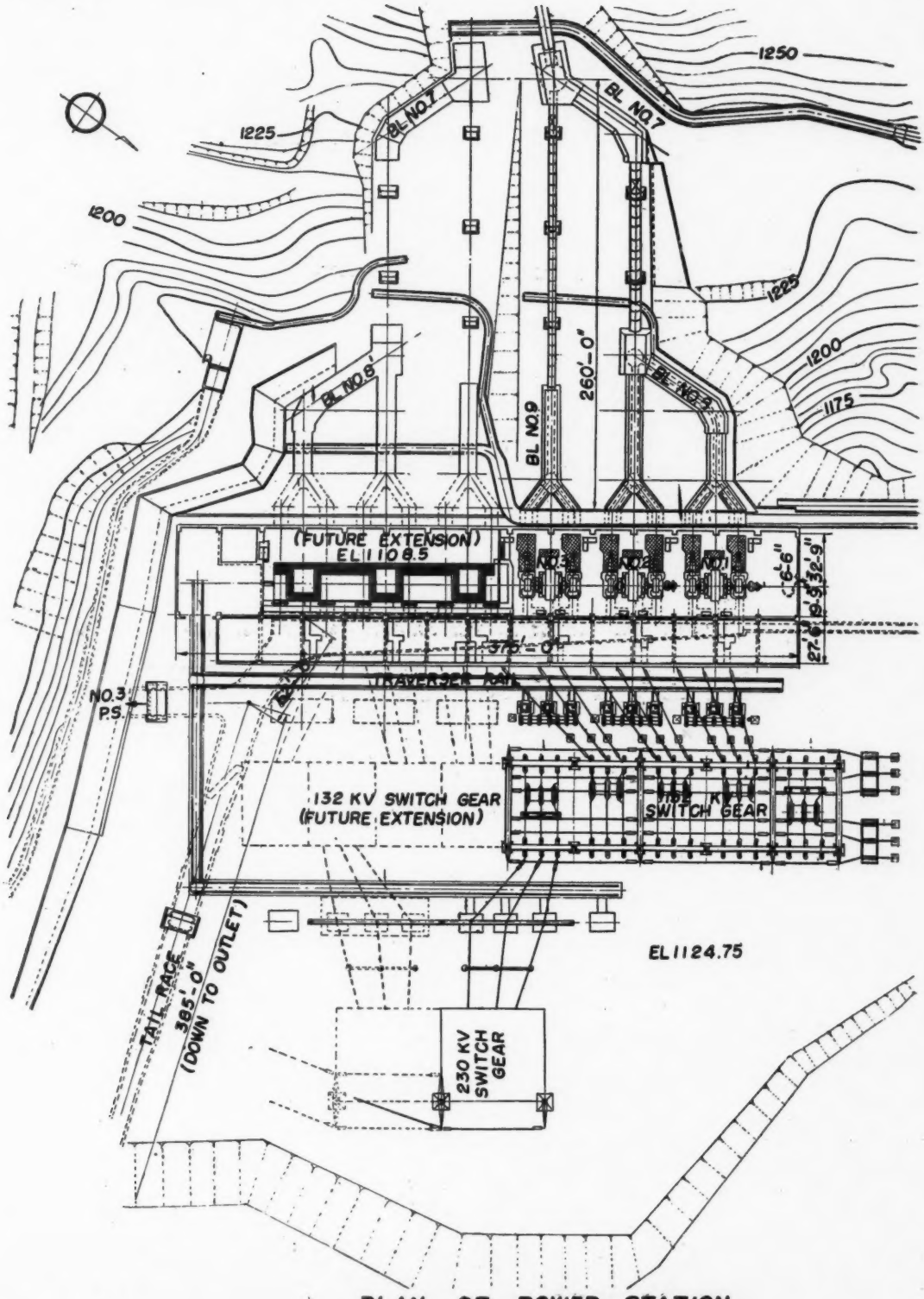
The services of Japanese nationals or juridical persons employed on this project and the plant, machinery and construction materials obtained from Japan are procured under the Reparations Agreement negotiated between the Government of the Union of Burma and the Government of Japan.

PROGRAMME OF IMPLEMENTATION

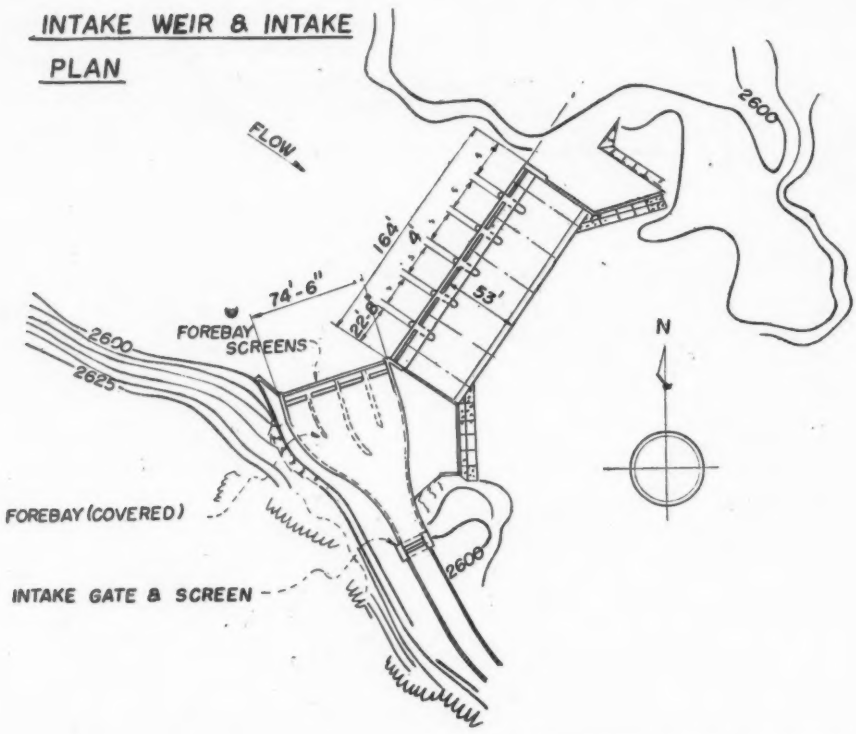
The programme of implementation and construction of the first stage development of the project for an initial installation of 84,000 kW plant is given below:

1954 *and* 1955:

Detailed investigation and design; procurement and transportation of earthmoving and general construction equipment; construction of access road from Loikaw to project site (18 miles); housing for staff and labour; erection of 1,500 kW construction disel



PLAN OF POWER STATION



power plant, workshops, godowns and ancillary works; job-site clearing; survey and construction of Loikaw-Toungoo Road (120 miles); planning, scheduling and setting up of organization for construction.

1956:

Preparation of Tender Specifications and award of contracts for construction materials, generating equipment, penstock, Transmission Line to Rangoon, etc.; excavation and foundation preparation of civil engineering works and continuing programme for construction of roads, bridges and ancillary works.

1957:

Continuing programme of procurement and transportation of materials and equipment, and of excavation and foundation works at job-site; erection of Crushing Plant, Concrete Batching and Mixing Plant, Rope Haulage etc.; Manufacture of Generating Plant, Penstock, Transmission Line Materials, fabricated steelwork, etc.

1958 *and* 1959

River diversion works, construction of Intake, Weir, Waterway, Pondage, Pipe Line, Surge Tank, Penstock and Power House; erection of Generating Plant, Transmission Line and Rangoon Sub-station.

1960:

Site tests, test operations and supply of power to Rangoon; continuing programme for Northern Transmission Line and Sub-stations.

CONSTRUCTION OF NO. 2 POWER PLANT

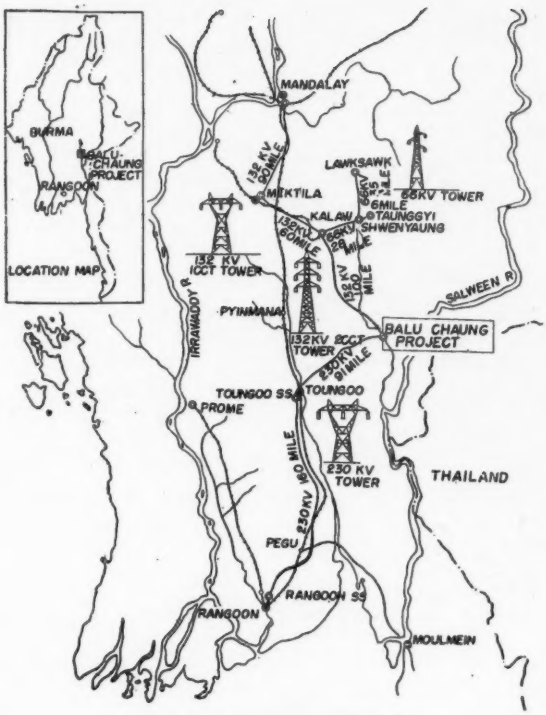
The principal features of the construction works of No. 2 Power Plant comprise an Intake Weir from which water is conveyed by a concrete channel Head Race to an open tank, which provides pondage for diurnal regulation of flow. From this Pondage, the water flows through a Concrete Conduit and then by a Low Pressure Pipe Line up to a Surge Tank which is located on the top of a cliff. Thereafter, the pipe line follows a steep downward gradient forming High Pressure Pipe Line or Penstock terminating at the Power Station below. The Power Station will accommodate initially three generating sets and has provision for installing three additional sets for the second stage development, when an additional Pipe Line and Penstock will be provided. The headworks and waterway up to the end of the Concrete Conduit are designed and constructed to meet the required capacity of the second stage development.

Brief particulars of these construction works are described below:—

Hydel Works

Weir:

Type	:	Concrete overflow type low dam fitted with six control gates.
Foundation	:	Floating foundation supported on steel sheet piles and wooden piles in limestone formation.



MAP OF TRANSMISSION NETWORK

Height of Dam	:	7′-6″ up to Spillway crest.
Crest Length of Spillway Section	:	164′-0″
Gates	:	6 nos. of Roller Gates of size 22′-6″ wide×8′-6″ high.
Type	:	Reinforced concrete free flow type with forebay.
Inlet	:	Forebay 74.5 feet wide with four 15 feet screens. Effective height 7′-9″, width 60′-0″.
Gate	:	1 no. of Roller Gate 15′-0″ wide ×10′-6″ high.
Screen	:	1 no. Movable Screen, 15′-4″ wide× 12′-6″ high.
Headrace:		
Type	:	Reinforced-concrete rectangular channel and Box conduit 15′-0″ wide & 10′-6″ deep with inverted syphon at river crossing.
Length	:	Open Channel..... 6,395 ft. Box Conduit.....4,390 ft. Total.....10,785 ft.
Maximum Velocity	:	10ft. per second
Discharge Capacity	:	1,500 cusecs.
Longitudinal Slope	:	1/640.
Pondage:		
Type	:	Reinforced-concrete walls with syphon spillway outlet capacity 1,500 cusecs.)
Layout	:	Elliptical 960′-0″×360′-0″ with a central guide wall forming two compartments.
Area	:	300,000 Sq. Ft.
Capacity	:	3,000,000 Cu. ft. for 10 feet draw-down.
Gate	:	Roller Gates—2 nos. 12′-0″×11′-3″ at Inlet and 2 nos. 12′-0″×18′-2″ at Outlet.
Screen	:	4 Movable Screens 12′-0″×18′-2″ at 1-3/4″ pitch at Outlet.
Low Pressure concrete conduit:		
Type	:	Reinforced concrete-shell 15″ to 18″ thick.
Size	:	Circular with 14′-0″ inside diameter.
Length	:	2,590ft. ending at Steel Bifurcation with two 9′-4″ diameter Butterfly Valves
Velocity at Max. Discharge	:	9.7 ft/sec.
Maximum Discharge	:	1,680 cu. secs.
Low Pressure Pipe Line		
Type	:	Welded Steel pipe line with ring girder supports.
Lines	:	1 line for the first-stage and another line for the second-stage.
Length	:	3,568 ft.
Inside Diameter	:	9′-4″ to 9′-0″
Thickness	:	3/8″ to 7/16″
Surge Tank:		
Type	:	Elevated Steel Differential Surge Tank of non-overflow type.
Riser	:	Inside diameter 7′-6″.
Tank	:	25′-0″ diameter (inside); 80 ft. high.
Height	:	203 ft. from the base.
Penstock:		
Type	:	Welded steel Penstock with ring girder.
Number	:	One line for first-stage and another line for second-stage.
Steepest gradient	:	38°.
Inside diameter	:	9′-0″ at the top end gradually tapering to 7′-2″ at the lower end branching off to 2′-9″ to feed the turbines.
Length	:	3,176 ft.
Thickness of Pipe	:	7/16″ to $1\frac{11}{16}$″.
Power House:		
Type	:	Steel framed Reinforced Concrete structure 375 ft.×80 ft.
Flow area	:	34,600 sq. ft.
Outdoor Switchyard	:	60,000 sq. ft.
Tailrace:		
Type	:	Reinforced concrete channel.

Gate	: 2 nos, steel sluice gates—one 13′-0″×13′-0″ and the other 15′-0″×13′-6″ for the inlet of No. 3 Power Station.

GENERATING EQUIPMENT

Initial installation at Balu Chaung No. 2 Power Station comprises:—

Water turbine	: 428.5 R.P.M., 40,000HP....3 nos. (Ultimate 6 nos.) (Horizontal-Shaft, Double-Runner, Four-Jet type Pelton Wheel)
Generator	: 31,000 kVA, Three Phase Voltage 11 kV, P.F.=0.9....3 nos.
Transformer	: 11/132 kV, 10,300 kVA, Single Phase.....10 nos.
Boosting Transformer	: 132/230 kV, 33,333 kVA, Single Phase.....4 nos.,
Switchgear	: Air Blast Circuit Breaker.
Auxiliary Equipment	: 2 nos. 60 tons Overhead Cranes.

TRANSMISSION SYSTEM

Power from Balu Chaung will be transmitted up to Rangoon in Lower Burma and to Mandalay in Upper Burma covering important parts of Central Burma and the Shan States by means of secondary and distribution lines.

Transmission to Rangoon will initially be by a single circuit 230 kV line, 250 miles long, with primary Sub-stations at Toungoo and Rangoon (near Hlawga Lake). The capacity of this transmission line is 90,000 kW. The Sub-station equipment comprises:

For Rangoon	: Transformer	20,000 kVA...4 nos.
	Synchronous Condenser	30,000 kVA...1 no. (initially)
For Toungoo	: Capacity	33,000 kVA

Northern Transmission Line comprise 240 miles of 132 kV Line to Kalaw, Meiktila and Mandalay with 65 miles of 66 kV Secondary Line to Taunggyi and to Lawksawk. The Northern Sub-station capacities are:—

(i) Kalaw	.. 14,000 kVA
(ii) Meiktila	.. 15,000 kVA
(iii) Mandalay	.. 15,000 kVA
(iv) Taunggyi	.. 6,000 kVA
(v) Lawksawk	.. 2,000 kVA

ROAD CONSTRUCTION

Associated with the implementation of the Hydro-electric project, is the extensive road construction programme comprising:

—Construction of 18 miles of access road from Loikaw through Lawpita to No. 2 Power Station.

—Construction of Loikaw-Toungoo Road, 138 miles long, of which 120 miles of the road is entirely new construction in extremely mountainous region. This road is built for the primary purpose of constructing the 1230 kV Transmission Line to Rangoon via Toungoo.

—Reconstruction of Loikaw-Pinlaung-Aungban Road, 100 miles long, following the old alignment, with new bridges and culverts. This road is used for transportation of some 40,000 tons of materials and equipment required for coustruction from the railway receiving station at Aungban, where a large Transit Depot is established.

Construction of bridges and culverts include Mobye Bridge (300 ft. span) and Loikaw Bridge (250 ft. span) to carry 60ton load; 49 nos. of Bailey Bridges of total span of 900ft. along Loikaw-Toungoo road and 46 nos.of total span 1,302 feet along Loikaw-Aungban Road; 859 culverts for a total span of 2,136 feet on Loikaw-Toungoo Road.

STATISTICAL DATA

Balu Chaung:

Catchment Area	3,180 sq. miles
Average Annual Rainfall	
Upper Catchment (Taunggyi Side)	65 in.
Lower Catchment (Loikaw Side)	45 in.
Annual outflow at Loikaw:	
Average	62,000 Million cu. ft.

Inle Lake:

Water-spread	48,800 Acres
Storage Capacity	13.3 Billion cu. ft. (At mean W.L. 2,906.5)

Mobye Reservoir:

Effective Capacity	13,350 million cu. ft. (30,700 Acre feet)

Balu Chaung No. 2 Power Plant:

(i) Hydel Works	
Earth-work	410,000 cu. yd.
Rock Excavation	215,200 cu. yd.
Concrete	86,400 cu. yd.
Construction Plant and Equipment	1,700 tons
Pipe Line, Surge Tank and Penstock	3,200 tons
Gates and Screens	200 tons
Generating Plant	2,500 tons
Boosting Equipment	230 tons
(ii) Construction Materials	
Timber	7,300 tons
Aggregates	120,000 cu. yd.
Explosives	120 tons
Steel Sheet Piles	960 tons
Cement	21,000 tons
Pozzolith	100 tons
Reinforcement Bars	3,600 tons
Structural Steel	500 tons
Power House Steelwork	440 tons
Pipes and Hardware	400 tons
Building materials	1,120 tons
Miscellaneous	1,500 tons

Access Road from Loikaw through Lawpita to No. 2 Power Station:

Distance	18 miles
Earthwork	344,400 cu. yd.
Rock Excavation	214,100 cu. yd.

Loikaw—Toungoo Road:

Earth-work	1,726,000 cu. yd.
Rock Cutting	50,000 cu. yd.
Stone Gravel	141,000 cu. yd.

Principal distance & elecvations:

	Mileage	El.
Toungoo	0	162
Thandaung Rd. Junction	7/5	250
Leiktho	33/1	2902
Thaukyegat Chaung	56/4	1471
Yado	72/0	3598
Htuchaung	83/5	2966
Hsehsuku	103/1	5031
Mawchi Road Junction	127/6	2954
Loikaw	138/2	2938

Principal Construction Equipment:

(*i*) *Earth-moving*

Bulldozer D-8		9
,, D-7		8
,, TD-24		3
Scraper Cat. No. 80		3
,, Euclid 12 ton		6
Power Shovel 3/4 cu. yd.		8
Dump Truck Euclid 12 cu. yd.		4
,, 5 ton		51
Motor Grader Carlisle & Cat No. 12		6

(*ii*) *Pneumatic*

Air Compressors:		
Portable	315 cfm	6
,,	210 cfm	4
,,	105 cfm	8
Stationary 120 HP	535 cfm	5
Wagon Drill	270 cfm.	4
,,	J.H.M.	6
Jack Hammer		61
Pick Hammer		20
Bits Sharpener No. 34		1
Bits Grinder		1

(*iii*) *Lifting & Haulage*

Truck Crane	18 ton	2
Mobile Crane	5 & 6 ton	3
,,	8 ton	4
Gantry Crane	30 ton	1
Derrick Crane	18 ton	1
,,	5 ton	2
Diesel Loco.	10 ton	1
Bray Loader	3/4 cu. yd.	3
Winch	15 to 30 HP	14
Rope Haulage	150 HP 15 ton	1
Portable Conveyor	30 ton/h	3
Heavy Wrecker	5 ton	2

(*iv*) *Concrete*

Impellor Breaker	20 ton/h	1
Stone Crusher	30 ton/h	3
,,	2½ ton/h	3
Crushing Plant	45 ton/h	3
Concrete Batching	37. 5c. u.yd/h	1
Mixing Plant	25. c. u.yd./h	1
Concrete Bucket	72cu. ft.	2
Concrete Pump	27c. u. yd./h	4
Crout Pump	1.13 cfm	2
Concrete Tower 8 cu. ft. ×70 ft.		1
Concrete Agitator Truck	2.7 cu yd.	7
Concrete Mixer	5 cu. ft.	11
Concrete Vibrator		24

(*v*) *Miscellaneous*

Pumps—Diesel	16 to 80 cfm	3
Pumps—Electric	8 to 173 cfm	35
Road Roller	8 to 10 tons	6
Sheep Foot Roller		2
Pile Driver	1 ton	3
Cement Gun		1
Mobile Workshop		1
Tank Car	400 & 1000 gals.	8
Saw Mill equipment		
Repairshop tools & equipment		
Motor Pool Equipment		

(*vi*) *Construction Power*

Diesel Generator	500 kW	3

(*vii*) *Transport*

Trailer Truck	25-30 ton	2
,, ,,	16 ton	10
Truck	7.5 ton	17
,,	5 ton	45
Power & Station Wagon		16
Pick up & 1/2 ton truck		29
Jeep & Land Rover		20

230 kV Rangoon Transmission Line

Length	250. 1 miles
Balu Chaung—Toungoo	95.7 miles
Toungoo—Rangoon	154.4 miles
Voltage	230 kV
No. of Circuit	Single Circuit

(*viii*) *Steel Tower*

Corset type Laltice Towers:	
Total Number	1,155 nos
Total weight:	4,414 tons

Classification:

Type A.....Tangential tower (suspension type)
Type B & B. a....
....Tangential and angle tower (up to 20 degrees)
Type C....Angle tower (up to 40 degrees)
Type D...Dead-end or angle tower (up to 60 degrees)
Type T...Transposition tower.

Standard height:	
Tangential tower	53 feet
Angle tower	45 feet
Standard span:	1,056 feet

Average span	1.142 feet
Longest span	3,690 feet
(ix) Conductor	
Size:	
A. C. S. R. (Al. 26/0.1749″ St. 7/0.1360″)	795,000 CM
Copper equivalent	0.338 sq. inch.
Weight:	2,720 tons
Earth Wire	
Size Galv. Steel wire	7/S.W.G. No. 8
Weight:	643 tons
Insulator	
Unit Disc	$5\frac{3}{4} \times 10''$ suspension insulator
Insulator string:	
Suspension string	15 units single)
Tension string	2×16 units (doube)
Total weight	664 tons

SUPPLY AND ERECTION OF GENERATING PLANT AND MAJOR EQUIPMENTS

Low Pressure Pipe Line, Surge Tank and Penstock: Nippon Kokan K. K.

Gates & Screens: Sakai Iron Works Co. Ltd.,
Turbines & Generators: Hitachi, Ltd.,
Switchgear : Tokyo Shibaura Electric Co. Ltd.,
Transformer: Mitsubishi Electric Mfg. Co., Ltd.,
Synchronous Condenser: Fuji Denki Seizo K. K.
230 kV Transmission Line to Rangoon: Nichimen Co. Ltd.,
Boosting Equipment: Hitachi, Ltd.,
Rangoon Primary Sub-station—Civil Engineering & Building Work: Clark & Greig (1949) Ltd., (Burma)

Earth-moving and General Equipment: Euclid (Great Britain) Ltd., Leyland Motors Ltd., Caterpillar Tractor Co., Ingersoll Rand Co., Hernischfeger International, International Harvester, etc.,

Rope & Haulage: Sumitomo Machinery Co. Ltd.,
Crushing Plant: Yokohama Kogyo K. K.
Concrete Pump & Grout Pump...Beton-Spritz-Maschinen GMBH West Germany
Batching & Mixing Plant: Nihon Kenki Co.
Stationary Compressor: Hitachi, Ltd.,

Continued from page 16]

Methods of Determining Consumptive Use of Water

season. The coefficients so developed for different crops are used to transpose consumptive use data from one location to others in which only climatological data are available.

Although it is recognized that use of temperature and precipitation are by far the most universally available data, these elements, together with sunlight have greatest influence on plant growth. Thus it can be assumed that consumptive use varies directly with the mean monthly temperatures, t, multiplied by monthly percentage of daytime hours of the year, p. Expressed mathematically:

$U = K\ F = \Sigma kf$

U = consumptive use of crop in inches for any period

K = empirical consumptive use coefficient (.60 to .85)

F = sum of monthly consumptive use factors for the period ($t \times p$)

k = an empirical constant

t = mean monthly temperature in Fahrenheit

p = monthly per cent of daytime hours of the year

$f = t \times p$ = monthly consumptive use factor.

This method was developed by H.F. Blaney and W. D. Criddle. The Blaney-Criddle method has advantages, since the percentage of daylight hours in any month for various latitudes are published. From these the consumptive use factors can be calculated for almost any crop.

For practical use, however, following assumptions must be made in applying the formula between areas:

(*a*) The fertility and producing power of soils are similar.

(*b*) Sufficient water is applied and at the proper time to maintain good growing conditions.

(*c*) The length of the growing season, to a large extent, determines the production and annual consumptive use of continuous growing crops.

(*d*) Consumptive use of water varies directly with the consumptive use factor.

In addition to the above, there are other formulas of Pennmen and Thorthwait which are also developed on climatological data. They are rather complicated for general use and hence are not discussed here.

Conclusion

The various methods described above have been used to determine the amount of water consumed by agricultural crops and natural vegetation. Regardless of the method, the problems encountered are numerous. The source of water used by plant life whether from precipitation alone, irrigation plus rainfall or ground water plus precipitation, is a factor in selecting a method. The facilities available for determining the factors involved in a particular method have also a bearing on the method to be selected.

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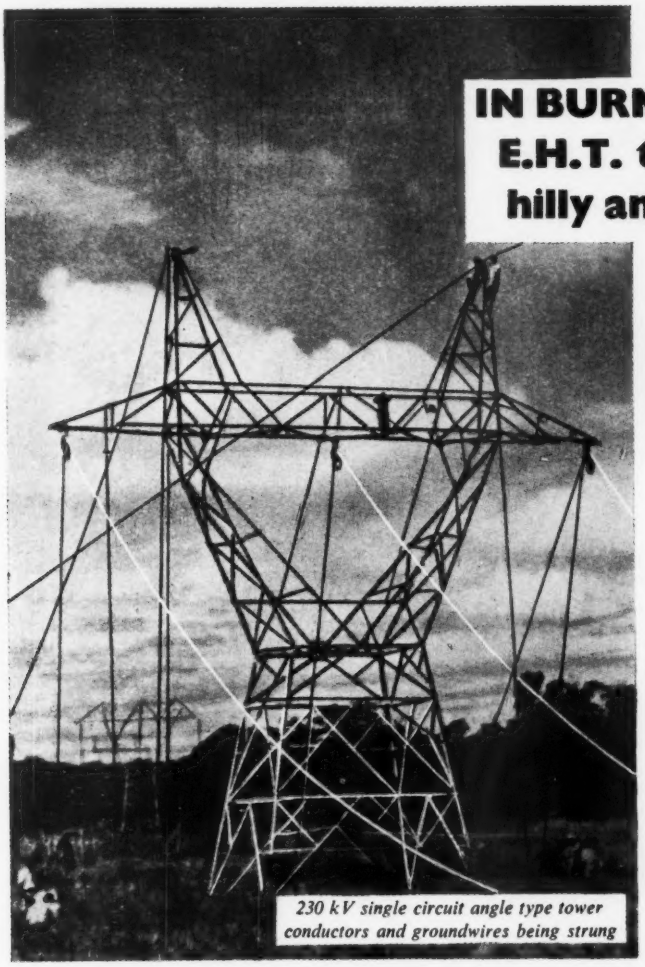

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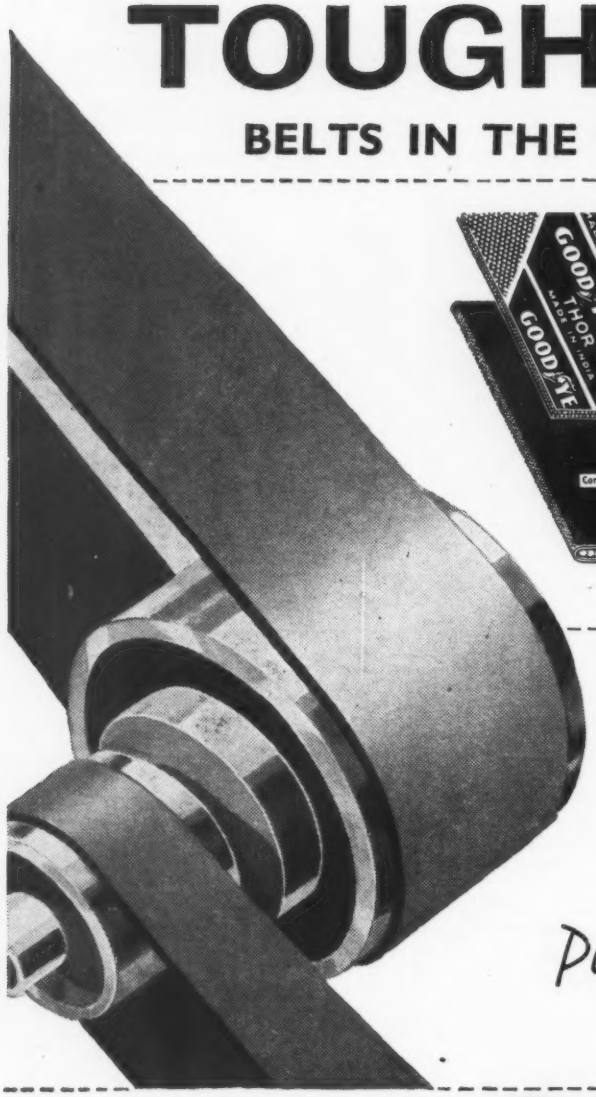

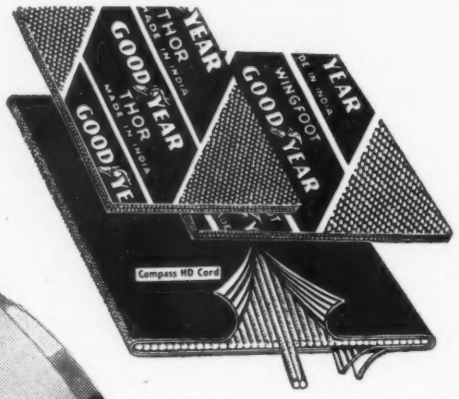

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Methods of Determining Consumptive Use of Water

By A. G. MIRAJGAOKER

Water is the most important factor in irrigated agriculture. In planning irrigation management, it is essential to know irrigation water requirements and consumptive use of water by crops. The amount of irrigation water needed on the farm and its distribution during the season depends upon the consumptive use requirements and on the efficiency with which the water can be conveyed and applied to the fields.

Consumptive use is one of the important elements in the cycle of water movement or hydrologic cycle, from the time it falls on the land as rain or snow until it reaches the ocean. It is the best index of how much water should be applied by irrigation for good production.

The determination of consumptive use and water requirements involves problems of water supply, both surface and underground as well as of the management and general economics of irrigation projects. A proper knowledge of water requirements has become an important factor in the arbitration of controversies over major stream systems where public welfare is involved.

New irrigation development is rapidly taking place all over the agricultural countries. New lands are being brought under irrigation. Older irrigation lands are being improved, and irrigation systems are being revised to have improved irrigation practices for better conservation of soils, water, and labour. Thus it is absolutely necessary to have a sound knowledge about the exact amount of water required for profitable crop production.

This paper is a review of the work done on consumptive use determinations by various methods.

Difinitions and Factors affecting Consumptive Use

Consumptive use may defined as the sum of the volumes of water used by the vegetative growth of a given area in transpiration and building of plant tissue and that evaporated from adjacent soil, snow, or intercepted precipitation on the area in any specified time divided by the given area. In other words it refers to the water taken up by the plants and transpired from plants and the water evaporated from the soil under the plants.

Consumptive use may be expressed in acre inches per acre (depth in inches) or acre feet per acre (depth in feet). For a twelve-month year, consumptive use is usually expressed in acre feet per acre or feet. Considered from a valley wide standpoint, consumptive use includes all transpiration and evappration losses from land on which there is growth of vegetation of any kind, whether agricultural crops or native vegetation plus evaporation from bare land and from water surface.

Consumptive use will vary for different crops and that for any given crop, the use will vary from year to year and from one location to another, with the length of the growing season, the average temperature, the precipitation, humidity, and the intensity of sunlight. Besides these climatic factors, there are numerous other factors which are also important, such as the character, condition, and treatment of the and the practice of water application.

The volume of irrigation water is not always a dependable indication of the water requirement of crop. Many factors may operate, singly or in combination, to influence the water usage and the effect of these factors is not necessarily constant but may fluctuate from year to year as well as from place to place. Some of these may be grouped as (1) natural factors, which include climate water supply, soil condition and topography; (2) physical factors, which include the main water supply canal for the farm, the division of the farm into smaller areas and the methods of irrigation; (3) factors of farm management and (4) economic factors as the cost of water, manner of payment, and permissible wastage, etc.

Several methods have been used to measure the consumptive use of water by crops and by native vegetation. We shall discuss the most useful methods in this paper.

Methods of Determining Consumptive Use

Various methods have been used by soil scientists and engineers to determine the consumptive use of water by crops and natural vegetation under field conditions. The methods most widely used in irrigation investigations are: (1) soil moisture studies on fields; (2) tank or lysimeter experiments; (3) ground water fluctuations; (4) inflow, outflow measurements; (5) integration methods; (6) effective heat; (7) correlation of water use to climatological data.

Soil Moisture Determination

This method is employed to determine consumptive use of irrigated fields on which the soil is fairly uniform and the depth to ground water is such that it will not influence the soil moisture fluctuations within the root zone. Soil samples are taken before and after each irrigation and at frequent intervals between irrigations. Usually a great number of soil samples should be taken. The total depth of water extracted from the soil by evapo-transpiration is computed for each period between the samplings.

In localities where practically no precipitation occurs during the growing season, this method is best suited and gives reliable consumptive use measurements. One advantage of this method is that it can be used on experimental plots of any particular size and the plots can be selected so as to be surrounded by similar crops or vegetation.

Tank and Lysimeter Experiments

One of the common methods of determining consumptive use of water by individual crops is to grow the crops in tanks or lysimeters and measure the quantity of water necessary to maintain satisfactory growth. Tanks as large as ten feet in diameter and ten feet deep have been used. However, in most consumptive use studies, the tanks are about two to three feet in diameter and six feet deep. The accuracy of consumptive use determination depends upon the accuracy of reproduction of natural conditions. Weighing is the precise means of determining the consumptive use from tanks, but conditions and facilities will not always permit the weighing of tanks.

Ground Water Fluctuations

Where a considerable area of irrigated land is relatively flat and when there is an adequate water supply, it is sometimes possible to estimate the average consumptive use of water for that area by an analysis of the fluctuations in the elevation of the ground water table. The procedure used is to install observation wells equipped with water stage recorders at representative locations in the area under consideration and to obtain graphic records of the ground water fluctuations. After an irrigation practice has been well established, the ground water table is usually somewhat higher than before irrigation. If there is a continuous inflow of underground water into the area and if the capillary water is within reach of the root zone of the crops, the observation wells give a fairly good idea of fluctuations in ground water levels. Then by making necessary allowances for irrigation water, precipitation, and knowing the specific yield of the soil it is possible to estimate the consumptive use for the area. This method has been satisfactorily used in Arizona, California, and Utah.

Inflow-Outflow Measurements

In theory, the inflow-outflow method requires an actual measurement of all the water entering the area. This should include both surface and sub-surface inflow and precipitation. Then the difference between the inflow and the outflow both surface and sub-surface plus the algebraic difference between ground water storage at the beginning and at the end of the period is the consumptive use in the given area.

In mathematical terms this can be shown as:

$$U=(I+R)+(G_s-G_e)-Q$$

When

U=the consumptive use for a period selected

I=the inflow during the period

R=the effective rainfall in the area for the period

Q=the quantity of outflow for the period

G_s and G_e are the volumes of water in ground storage at the beginning and end of the period.

In the investigations on Upper Rio Grande, Pecos River, and other valleys, this method was used to determine the total consumptive use of water in irrigated areas up to 400,000 acres.

Integration Method

Integration method considers consumptive use in a valley to be the summation of the products of the use of water by each crop times its area, plus the use of water by the natural vegetation times the area, plus water surface evaporation times water surface area, plus evaporation from bare land, times its area. Before the integration method can be used, it is necessary to know unit rates of use of water by the various agricultural crops and natural vegetation and the unit rates of evaporation from bare land and water surfaces. Unit values of consumptive use of water by crops can be obtained by some of the methods previously described. By means of aerial maps and field surveys the areas of various types of native vegetative cover and bare land and water surfaces can be determined.

Effective Heat

By this method, consumptive use is estimated from a study of the heat units available to the crops of a particular valley. It assumes that a linear relation exists between the amount of water consumed and the quantity of available heat. Studies by the U. S. Bureau of Reclamation developed a somewhat similar method which has been used quite generally in making its estimates of consumptive use.

In 1940, in connection with the Pecos River Joint Investigation, a method of estimating consumptive use by natural ground water vegetation and by irrigated crops having access to an ample water supply was developed. Correlation of the relatio n-ship between transpiration, evaporation, temperature, daytime hours, lenghth of growing season, and humidity was used in the estimate. In 1945 this method was modified to make possible estimates of consumptive use for areas in which humidity records are not available. This method has been used by Soil Conservation Service in estimating rates of water consumption in many areas.

Correlation of Water Use with Climatological Data

Actual measurements of consumptive use under each of the physical and climatic conditions of any large area are expensive and time consuming. The Soil Conservation Service developed a rapid method of transferring the results of measurements made in several areas to other areas. The procedure is to correlate existing consumptive use data with monthly temperatures, percentage of daytime hours, precipitation, and frost free period or irrigation

[*Continued on page 14*

Hydraulic Turbines—III

Parts I and II appeared in March and July this year—Ed.

By N. VENKATA ROW

GOVERNING

The speed of the turbine is to be constant irrespective of the load variations. This is the function of the governor. Variation in load causes variation in speed and this variable is used for varying the water to be admitted.

The quantity of fluid involved being very large the governor capacity should also be very large. A 60 MW steam turbine, hydrogen cooled, with working conditions of 850 psig-900 F-2" Hg requires about 500,000 lbs/hr. A hydraulic turbine of 44,000 hp working under a head of 40 feet consumes about 5000 times more of water. The weight of the water and its incompressible nature and the inertia of the slow moving long columns call for enormous amount of forces for regulation.

As stated above the variation of speed is the factor used for regulation. For transmission of speed from the main shaft of the generator to the regulating mechanism for a long time only mechanical means belts have been used. Now-a-days the transmission is by electrical means. The pendulum of the governor is now driven by a three phase motor so called pendulum motor which is fed by a three phase generator mounted on the main shaft of the generator-PMG. The generator can be mounted in the upper part of the excitor assembly or between the rotor end and the guide bearing of a horizontal installation.

The force developed by the fly-balls driven by the motor is used for control of a valve which in turn controls the passage of the pressure medium such as oil into one or more regulating cylinders which apply the relayed force to the turbine gates or nozzle as the case may be. In the case of the Kaplan turbine the blades also have to adjusted.

In impulse turbines in order to avoid excessive pressure rises, where the supply lines are long the governor control is brought to bear on the jet deflector for diverting the water away from the buckets. This is followed by a separate movement of the flow controlling needle at a rate slow enough to suit the pipe line conditions.

For Francis turbines to avoid pressure rise in the penstock it may be necessary to increase the gate closing time but this increases the speed. In such a case the water is diverted through a relief valve, which is also controlled by the governor.

The capacity of the governor may be arrived at from the formulae:

$$\text{Capacity ft. lbs.} = \frac{CP}{\sqrt{H}} \qquad (39)$$

Where HP Horse power
H head in feet
C a constant which is 40 for Kaplan turbines
50 for Francis
55 for propeller
30 to 35 for stream defection in case of impulse
40 to 60 for the nozzle control

$$G_s = G_1 D_s^2 H_m \qquad (40)$$

Where G_1 is unit servomotor capacity (Ns-10)/10
Gs servomotor capacity in ft- lbs
Ds discharge diameter of the runner in feet
H_m maximum head including watter hammer effect
N_s specific speed

$$\text{Capacity} = \frac{KP\sqrt[4]{N_s}}{\sqrt{H}} \qquad (41)$$

Where K 18 for gate operation of Francis
20 for Kaplan blade operation
34 for Kaplan gate operation

Plant	*HP*	*Head*	*Capacity in Lbs-ft*	
			Reg. Cyl	*Blade servo*
Pickrich	55000	48	663000	786000
Shasta	103000	330	354000	
Fontana	91500	330	266000	
Kentucky	44000	48	350000	598000
Rockisland	34000	45	298000	
Mc Nary	111500	80	840000	900000
St. Lawrence	79000	81	660000	

The Giljet governor is primarily for the control of the speed of Francis turbines having long supply lines. The principle of working is such that if a relatively small jet of water is allowed to impinge on buckets similar to impulse turbine buckets, fixed on a fly wheel the full power of the turbine is absorbed. The manufacturers can guarantee that the speed rise on full load rejection will not exceed 10%.

There is another type of governor manufactured by Nohab. In the conventional turbine governor the speed or frequency sensitive element consists of a pendulum which operates a hydraulic valve through link system. The restoring and compensating mechanisms, together with the speed changer, actuate the same vlave through another link system. In electro hydraulic regulator these operations are carried out in an electronic vlave regulator, which is fed with voltages representing the various quantities. This type of governors have become very popular in Sweden and most of the recent installations are equipped with these.

Bersimis Lac Casse Project

The project includes two large dams to give a storage basin. A seven and half mile tunnel of 31 feet diameter leads the water to the surge shaft. Though the rock was good not necessitating any concrete facing of the tunnel it still has been used as for the same hydraulic losses an unlined 45 feet diameter tunnel would be required. The tunnel is not exactly circular but of modified horse shoe type to allow trucks to pass each other and for turning around. As excavated the diameter was 35 feet. For a flow of 15,000 cfs the calculated loss of head is 48.5 feet.

The surge tank is designed to limit the pressure rise to 25% on full load rejection. Due to the great momentum of the water travelling at 19 ft/sec in a tunnel of 31 feet diameter a tremendous energy is necessary to stop the flow in 4.75 secs. which is the time taken for the wicket gates to close. The surge shaft is said to be the largest known. The upper section is 85 feet in diameter and depth 365 ft.

Eight penstocks take off from the discharge end of the tunnel. The power house is located in underground and houses eight turbines. Economic considerations and necessity to charge long transmission lines warrented selection of large capacity units. The units are spaced 55 feet centres. The powerhouse is 554 ft wide with erection bays of 100 ft and 25 feet on either end and 57 ft wide and 31 feet high.

Eight Francis turbines with a rating of 150,000 HP 277 RPM at a minimum head of 785 ft are installed. Mechanically they are designed to withstand a maximum head of 875 feet plus 25% surge. Under the maximum head they can generate 200,000 Hp. The turbines are supplied by English Electric company of Canada Ltd. The single piece casings were made by George Fisher Ltd of Switzerland.

Each runner is 12 feet in diameter with a discharge diameter of 8½ feet and inlet height of 14 inches, weighing 20 tons. As these are high head Francis turbines special precautions are to be taken in the choice of the steel, sealings etc. For reasons connected with tensile strength it has been necessary to use stainless steel for the castings. The sealing chambers being subjected to different pressures seals of stainless steel are used against special alumunium bronze alloy.

The setting of the turbine is low, the center line of the distributor being at elevation 422, 3 feet below the low water level and 18 feet below the high water level. As operation at light loads is expected a further effort to reduce cavitation has been made by aeration through the center of the runner.

The generators are rated for 138MVA at 95% p. f. with short time rating of 234 MVA at 0% p. f. leading for charging requirements. The scr is 1.3 The power is stepped up to 300 kV for transmission to Montreal located 300 miles away.

A project of this type could be taken on hand mainly due to the recent experience and progress in design of high voltage lines, tunneling underground installation, construction of high capacity generators and turbines, H. T. switchgear and micro wave system of communication.

A Kaplan Turbine Installation

Jochenstein on the river Danube is one of a series of 14 stations to be developed by Germany, Austria and Bavaria. This station is located about 19 miles below Passau. Here the minimum flow is 13000 cfs with a usable head of 42 feet. Mean flow is 50,000 cfs at a head of 33 ft. Five Kaplan turbines of identical size are installed with characterstics

Head	31′ 6″
discharge	12400 cfs
Speed	65.2 RPM Runaway speed 177
Output	39400 Hp.

Three are of Voith make and two of Escher Wyss. The runners are of 24′3″ in diameter-ranking among the largest sized units and each weighs 690 tons. For each runner there are five blades. The blades are of heat treated cast steel with stainless steel prewelding to reduce cavitation. The head cover is a welded plate split for ease of transport.

The turbine shaft has a mean diameter of 33 inches bored hallow to house the regulation rod. The shaft bottom end is fitted with a flange for fixing of the runner and top end provided with a bolted on servomotor cylinder for runner blade regulation.

There are two guide bearings—lower in the head cover and upper in a special bracket—and a thrust bearing. The latter is designed for a hydraulic thrust of 950 tons.

Twelve separate cast iron stayvanes are used, the lower ends are embedded in concrete with anchor plates and the upper ends re bolted to the welded stay ring supporting the generator.

The draft tube for a distance of 24'77" is lined. At the top the tube is circular slowly changing to rectangular shape at the exit.

Each generator delivers 35MVA at 0.8 P. F. 9000V 50 cps. The voltage is directly stepped up to 220 kV. Each generator weighs 315 tons.

The flood discharge of 340,000 CFS about 5½ times the turbines capacity is handled by six sluice gates each discharge 60,000 cfs. These gates are located on the Austrian side. The lock for handling the river traffic is located on the Bavarian side. There are two locks 79 ft wide and 755 ft long each. Each lock can accommodate a tugboat and four barges.

ADVANCES

In the design of the hydraulic turbines there has been no significant change since the development of the Kaplan turbine. Developments have concentrated:

1. for attainment of higher efficiency
2. for increase in the capacity
3. to extend the range of operation of the reaction tubes
4. for better utilisation of the material

Efficiency: The present levels of efficiencies are 93% for Kaplan, 92% for Francis and 90-91% for the impulse turbines. These are of an indicative nature only as the maximum attainable efficiency depends on the specific speed of the runner also. Very high values have said to have been obtained in the case of some installations. These high values are attributed to the inherent inaccuracy of the flow measurements. A slight inaccuracy in the water quantity, where large amounts are to be handled, measured offsets the efficiency sizably. A 2% tolerance is allowed in the efficiency guarantees in all standards excepting the ASA. Because of the inherent deffiiciency tests on models have become the standard practice for efficiency guarantees. Even the values obtained from the models are being viewed with a doubt with regard to accuracy as the step up formulae are of emperical nature.

Francis vs Pelton: The advances in the laboratory technique in parallel with metallurgy have helped in extending the field of application of reaction turbines. Francis have entered where pelton were common and Kaplans have entered the field where formerly Francis have been used. There are border line cases where either type can be used. A number of factors have to be considered while selecting in such cases.

For the same hydraulic conditions the Francis turbine efficiency curve is not so flat as that of impulse but for loads—approximately—65%-100% it lies over whereas for lower loads it lies under the impulse efficiency curve. As the general practice is to run the turbines in the upper regions of the capacity better efficiences are obtainable with Francis.

With Francis higher speed is possible which results in lower capital investment both for machinery and the power house building. With higher speed due regard has to be paid to the strength of the generator under runaway conditions. In Francis it may be necessary to set the centre line of the turbine below the tail race level for reasons of cavitation. This results in additional excavation.

$$\text{Specific speed} \times \frac{\text{discharge diameter or the nozzle diameter of impulse}}{\text{inlet diameter of Francis or the pitchcircle diameter}}$$

In Francis this ratio cannot be reduced below certain limits without leading to inlet channels which are narrow, too long and difficult to manufacture. In Pelton it cannot be increased beyond a limit that is compatible with a sufficient number of buckets, robust connection between buckets and the hub and a proper evacuation of the water towards the centre line of the runner.

In Pelton the speed can be increased by increasing the number of jets but there is a limit to the number depending on the arrangement. Even then as high a speed as obtainable with a Francis cannot be attained. The overall dimensions of a Francis turbine will be appreciably less than for a Pelton alternative. This results in lesser spacing of the units.

In Francis the whole range of head down to the tail water level is used. In Impulse the the runner will necessarily have to be placed at least six feet over the high flood level. In respect of operating heads there will thus be a permanent loss which will be of the order of 0. 6% to 1.6%.

With regard to variation of head the reaction can accommodate up to 35% above the normal without undue change in characterstics whereas with Pelton it is 20%.

Condition of water will sometimes play a deciding role in the selection. In extreme cases of sandy water neither the Francis nor the Pelton can withstand the attack and a sand separating plant will have to be installed in any case.

The wear is dependent on the velocity of water issuing. In the Pelton the velocity of jet corresponds to the full head and hence the nozzles wearout quicker. With Francis the velocity is lesser being directed by the guide apparatus. Wear has a pronounced effect on the nozzles. Even a slight roughness on the nozzle gives considerable disturbance to the jet quite apart from the detrimental errosive action on the buckets. Efficiency may be reduced by as much as 6% at half load and 1.5% at full load even when the wear on the nozzle is of the order of 1/32 inch. In Francis the wear on the blades is uniform whereby the profile is deformed to a slight extent. This is due to the uniform distribution of water over the blade surface.

From the maintenance point of view another point also arises—repair. The needles and the nozzles in Pelton are designed so that they can easily be dismantled and replaced. The slight bucket damages can

be rectified by grinding and welding without removal of the runner. With the Francis even with all the care taken from the start of the design the total time taken for installing a spare runner and removing the protective rings will be about 60 hrs.

The following table gives comparision of a high head Francis and Impulse, assuming four units are being installed.

	Francis	*Impulse*
Head	1225	1215
Width of the Power house	28′	46′6″
Length (including a repair bay)	195′6″	233′6″
Spacing	34′6″	45′
Efficiency	over 90% 65-100% range	89.6% 60-70% range

Kaplan vs Francis

High efficiency favours Francis over Fixed blade propeller but Kaplan is more efficient than these and can be used for a greater range of head variation.

Higher speed of Kaplan results in lesser powerhouse dimensions. The runaway speed of the Kaplan is more than that of Francis and the generator mechanical construction needs special care.

The setting of the Kaplan warrants greater excavation. The cost of the turbine with its complicated blade mechanism and control apparatus is costlier than the Francis.

The maximum head for which each class of turbine is used has increased gradually—the maximum has been in the case of the Francis turbine 1670 feet and 230 ft in the case of the Kaplan. For the Impulse it is to 5800 ft only solely because there have not been higher heads harnessed.

SOME HIGH HEAD INSTALLATIONS

Station	*Country*	*Make*	*HP*	*RPM*	*Head*
Impulse					
Reisseck	Austria	Charmilles	31000	750	5800
Dixence	Switzerland	do	50000	500	5700
Fully	do	do	3000	500	5250
Mieville	do	do	47800	500	4750
Portillon	France	do	55600	500	4280
Francis					
Hemsil	Norway	Kvaerner	48500	750	1670
Fionnay	Switzerland	EWAG	63200	750	1490
Limberg	Austria	EWAG	77700	500	1430
Saifen	Switzerland	EWAG	58850	750	1380
Vinstra	Norway	Kvaerner	69000	500	1360
Faistrone	Italy	EWAG	20140	1000	1320
Kaplan					
Toyanama	Japan	Hitachi	17000 (kW)	400	230
Bort-rue	France	Neyrpic	318000	375	230
Barcis	Italy	EWAG	13600	500	199
Requejada	do	do	5730	500	180
Striking advances have been made in the unit capacities. For Francis the figure has attained 200000 Hp, Kaplan 105 MW, Pelton 150,000 Hp.					
Impulse					
Pragnieres	France	Neyrpic	100000	428	3920
Malgovert	France	do	101500	428	2425
Kitimat	Canada	Different Suppliers	150000	327	2485
Cimego	Italy	Riva	150000	300	2367
Francis					
Chute	Canada	EE	200000	200	540
Stornorrfors	Sweden	Nohab	200000	125	246
Bersimis	Canada	EE	175000	277	875
Grand Coulee	USA		165000	120	330
Bortlesorgues	France	Charmilles	150000	187.5	336
Chastang	France	do	135000	150	233
Tokke Kr Verk	Norway	Kvaerner	150000	375	1240
Kariba	Rhodesia	EE	140000	167	280
Snoey Ti	Australia	EE	134500	375	1095
Harspranget	Sweden	kMW/Nohab	133000	167	344
Sungari	Manchuria	EWAG	115000	125	226
Furnas	Brazil	Nohab	225000		324

In the case of the Kaplan turbines the capacites have increased quite rapidly. With low heads that the amount of water to be handled will be very high and this call for enormous regulating force.

For large schemes using Kaplan turbines it is of importance that the limitations of maximum size and weight are known, since this is the limiting factor of the output that can be obtained from one unit. The largest and heaviest single part is the hub casting which cannot split. The present limit of the hub diameter is 10 to 11 ft. Theoretically we can obtain with this limit 15000 Hp at 14 feet, 74000 Hp at 60 ft. and 120000 HP at 95 feet.

The Kaplan turbines of the Vargon plant in Sweden still hold the record (from 1937) for dimensions. There are quite a few interesting features about this plant.

The installation is of a semi-outdoor type. The generators are protected by steel plate covers which can be removed. Each turbine develops 15200 HP at 14.1 ft and runs at 46. 9 RPM. The runner is 26 ft in diameter and the hub 106 inches. Siphon setting has been used wherein the lower edge of the guide vanes are in level with or slightly above the maximum head water level. The inlet is so arranged that the guide wheel and the runner chamber form a closed space. On starting up this closed space must be evacuated either by ejector or vacuum pump and the turbine will be stopped by readmitting the air. The inlet gates are therefore not necessary. This arrangement is not suitable for heads over 13-16 ft.

The runner and the inlet dimensions are such that ice and lumber brought by the river can easily pass through; no sluice gates or screens are installed.

Some of the large size physically and in capacity installations:

Station	*Country*	*Head*	*HP*	*Speed*	*Runner diam.*
Reckingen	Switzerland	32.8	26700	75	20.27′
Dogern	do/German	37.7	38000	75	23′
Bonneville	USA	50	66000	75	23.3′
Birsfelden	Swiss/German	30	30000	68.2	23.6′
Swir	USSR	36.1	37500	75	24.3
Jochenstein		31.6	39400	65.2	24.3
Jark vissle	Sweden	43	59500		25
Pickwick	USA	43	48000	81.8	24.3
Ligg	Sweden	130	105900	125	
McNary	USA	80	111300	85.7	
Dallas	USA	81	123000	90	
Porsi	Sweden	118	131000	115	
Sanake river		89	143000	90	

The Kuibyshev and the Stalingrad stations on the river Volga have giant Kaplan turbines, the former 20 and in the later 22 indentical units, each of 105 MW. The speed in both the cases is 68.2 RPM. The runners are 9.3 m in diameter and are designed for an abnormal discharge of 675 Cm/s under a head of 19 m. With the increase in capacities and the operating heads there have been corresponding developments in the materials of constructions.

In Europe single piece castings are preferred. The most favoured grade of stainless steel is 12 to 14% Cr with or without nickel. These alloyed steels offer great resistance to cavitation, can be treated for obtaining high mechanical strength and can be field welded. Bronze has been used as it resists pitting.

In the case of the Piottino turbines considerations like higher speed, fluctations in tail water level lead to the selection of Francis type runner. These represented the highest head turbines of Francis turbine at the time of their installations. Each is rated for 33000 Hp at a head of 323 m running at 750 RPM at the time these turbines were built (1932) stainless steel technique was not sufficiently developed to allow this material to be used for castings as complicated as Francis runners. To reduce the risk of cavitation special bronze runners were cast. These have excellent service.

Even stainless steel which has high resistance to pitting doesn't have equally good resistance to erosion. Aluminium Bronze—Ampco Bronze—offers good re-resistance to erosion. Experience of Ontario Hydro was said to be satisfactry with this material. A great drawback is that it cannot be welded overhead. The runner has to be removed from the casing. The flat iron Francis runners are of Ampco Bronze. This was selected mainly due to shortage of stainless steel at the time of manufacture of these turbines.

In recent years there has been a greatly increased use of plate and fabricated construction, which affords reduction in weight and welding has almost completely superseded riveting.

The variety of designs consequent to the peculiar conditions of each installation emphasizes the advantage of this type of construction, considered as a substitute to castings in smaller components with all the accompanying savings of pattern costs or for the larger structures. There are no serious material limitations.

The service duties of many turbine parts implies in addition to static loading heavy dynamic stresses

which in turn accentuates the importance of first class welds. The intrinsic uncertanity of casting can be avoided. Experience has also shown that accurate forecasting of the precise solidification of a casting is a task of utmost difficulty particularly as applied to complicated castings or new designs. Only manufacturing experience over prolonged periods can give consistency as regards the finished product.

Mention may here be made of the Krangede (Sweden) Francis turbines of 47,000 Hp output under 57.7 meters nett head operating at 167 RPM. Inspite of the long experience of the steel works, in shrinkage and deformation, the final outlet openings came greater than intended. At tests an overload of 14% was obtained compared to 10% stipulated. Since the generators were able to withstand the maximum output the guide vane opening was not limited. Subsequently pitting was developed because of cavitation. The runners being of cast steel the effected areas were covered with stainless steel. Attempts were made to change the shape of the runner blades to avoid pitting but according to the model tests only the efficiency decreased but no increase in safety against cavitation. Defects in castings are, in many instances, discovered at an advanced stage of manufacture resulting in disorganisation of the manufacturing schedule.

—The advantages of the present trend to breakdown structures into simple cast shapes or a mixture of cast, rolled or forged forms.

—Founding and pattern making techniques are simplified.

—The cleaning, grinding and inspection techniques as applied to the individual parts are carried out much more easily.

—Simplification of machining techniques; considerable premachining is possible prior to the welding assembly.

—There is expansion of available sources of supply regards foundries etc., due to the less complicated nature of the individual parts.

—if components are carefully assembled and welded accurancy of passages can be obtained within plus or minus 1% of design areas.

Against these advantages the following disadvantages have also to be taken note of :

—the physical size of the welds is heavy and in such location and of such shape that automatic welding may not be possible. Intermittent stress relief is necessary with heavy welds to avoid cracking.

—since many structures particularly the runners are to be produced to close tolerances the control of distortion becomes a major factor.

—due to this size of the welds it is necessary to strike a balance between the amount of mechanical reinforcement necessary to control distortion as compared to the danger involved with highly restratined welds.

—preheating is necessay and this may be either by gas electric induction or resistance as the case may be depending on the location. On account of complicated shapes gas heating is generally adopted.

Shop procedures for fabricating the runners from components have been evolved. The band and crown are cast seperately and machined. The bucket pattern is made from wood and used as a template for casting the master pattern. Each bucket is finished separately. During the whole stage of manufacture several stress relieving operations are required. The blades can also be hot pressed from plate steel. The attainment of the critical shape as a result of the pressing operations calls for the most careful control and standardization of such variables as preheating and pressing temperatures, the speed of transfer from furnaces to dies and the duration of the pressure period. Some notable installations where fabricated runners have been installed are:

Plant	*Country*	*Power HP*	*Head ft.*	*Runner Diam. ft*
Loch Sloy	Scotland	45000	880	—
Snowy Tl	Australia	134500	1105	9′3″
Los Peares	Spain	73000	306	9′5″
Salto de Castro	,,	59000	125	15′11″
Eildon	Australia	82100	235	12′5″

The 140,000Hp runners for the Kariba Projects, South Rhodesia will be the most powerful runners of the fabricated type. The Salto de Castro runners which weigh about 44 tons are believed to be the largest fabricated runners. Another example is the 52,500 Hp Francis runners for the Lock Out point installation in USA. Each runner is for operation at 128.6 RPM under a head of 165 ft., weighing 85000 lbs. The thirteen individual buckets, crown and band cast separately, inspected and repair welded, finish ground and thereafter welded into a single piece assembly. This is believed to the largest welded Francis runner produced in America.

Savings in weight and cost by use of welded casings has been an incentive for using this type now-a-days. For hydraulic turbines, the usual maximum design stress for cast steel is 10,000 lbs/sq. inch while for plate steel it is 12,000 lbs/sq inch. This alone represents a saving in quantity of steel. As there are no projecting parts inside higher velocities can be used and this results in reduction of dimensions.

Typical examples are the Boulder Dam and Grand Coulee dam Installations. In the case of the former the first twelve turbines are with cast steel casings. Two additional were with plate steel casings. Comparisions show that the finished welded plate casing weighs 30% less than the cast steel casing and costs

20% less to manufacture. The riveted casing of Grand Coulee weighs 392,000 lbs. as against 218,000 lbs. for welded one.

Mr. R. A. Sutherland on an analysis of some installations arrived at :

Weight of casing lbs. $= Cd^3 Hh^{1/4}$

H design head in feet
d inlet diameter in feet
h rated head in feet
C 0.066 for riveted casing
0.50 for a fully welded casing

The field welding of casings is however not commonly accepted by the manufactures. In the case of Fontana, Shipshaw, Cheoah and Los Peares the casings were welded at site.

The Fontana turbines work under a head of 245/435 ft and have spiral casings with 12 ft inlet diameter. Plates of $1\frac{1}{8}''$ to a $1\frac{7}{8}''$ thickness have been used. The stay ring is built of cast steel in five sections and the spiral casing in 8 sections. Circumferential sections were welded in shop and the longitudinal sections were welded in the field.

Plant	*Country*	*Power Hp*	*Head Ft*	*Inlet diam. Ft*	*Remarks*
Shipshaw	Canada	100,000	208	16	
Grand Coulee	USA	165,000	330	15	
Table Rock	USA	68,000	190	16′9″	
Snowy Tl	Australia	134,500	1105	6′	
Hungry Horse	USA	105,000	400	11′	
Bull Shoals	USA	62,000	190	14′8″	

For 3 and 6 the joints were riveted, 2, 4 and 5 flanged and 1 welded. Allthe casing sections were shop welded.

The Snowy Tl turbines casings have a maximum thickness of $2\frac{1}{4}''$. In addition to having to withstand a test pressure of 900 lbs/sq inch every weld is fully radiographed to ensure soundness. The adoption of welded casing instead of cast steel casing is said to have resulted in a saving of 7 to 8% possible.

In addition to welded casings there is a trend towards welded head covers, stay rings and wicket rings also, what were believed to be the first welded stay rings were used for the 7th and 8th units of Arapuni station, New Zealand. These were 14 ft in diameter weighing 20 tons. Another example of fabricated stay raings is the 131,000HP Kaplan Priest Rapids installations. Each ring is 37′6″ in diameter weighing 100 tons.

At Bonneville for some of the turbines fabricated parts have been used extensively. The stay rings, head covers, bearing housings pit liner, draft tube liner etc. were all of welded construction. Inspite of very adverse operating conditions during the war these units have given satisfactory service.

Los Peares is another installation where welding has been used extensively. Each turbine is rated for 72,800 HP at a maximum head of 305 ft. The maximum efficiency occurs at 262 ft. Each unit is fed by a separate penstock. The spiral casings are of plate steel fabricated in sections at works and welded together at site. The stay ring is also of welded construction and consists of two steel rings with vanes between them.

It is 18 feet in diameter and weighs 22 tons. The runners are of cast steel with an inlet diameter of 8′6″, and a total weight of 13 tons. The 18 buckets are machined to correct shape and welded in place. After assembly the blades and the outer band were welded with stainless steel to protect against cavitation. The blade surfaces were ground to fine finish. The runner band and hub were machined and fitted with renewable wearing rings of stainless steel.

PUMP TURBINE

In Europe most of the pumped storage installations have three machines-turbine, pump and generator-motor. This has also been the case in the other parts of the world. In 1938 Voith developed a reversible pump-turbine for the Pedreira Plant in Brazil to operate under a head of 75 ft and discharging 600 cfs. Subsequently till 1949 there has been no development. The present trend is to have reversible pump-turbines for storage installations.

With a runner-impeller connected to a generator-motor, a spiral case to lead the water to or away from the pipe line, a pump-turbine looks like the conventional turbine of Francis type. There can be movable wicket gates around the runner-impeller to control the flow of water or no wicket gates at all. With the former arrangement the gate position can be changed with the change in the reservoir level to get best efficiency, while pumping. Further the gates can be used for synchronising. If there are no wicket gates a butterfly valve is provided and used for synchronising.

Generally the units are of high horse power. With the wicket gates or butterfly valve closed, while starting, the unit draws very high power, which will cause a disturbance in the system. To reduce the disturbance the water in the impeller is depressed by compressed air and then the unit is started, in which case the power drawn is 3-5%. of full load power. When once the unit attains speed the air is slowly released and the water level rises.

A reversible pump-turbine can be built for the same range of sizes for which a francis turbine is built. They can be built to 150,000 HP if a motor-generator of matched type can be made. The impeller runner can be cast in sections and bolted at side, to meet the loading gauges. The Hiwassee unit was made in three sections as its diameter is over 22 ft.

The units can be built for heads as low as 50 ft. and as high as 1200 ft. A pump-turbine is not meant for regulating the load but for supplying large blocks of power. It can hence have a slow acting governor.

Extensive model tests have revealed that

—for heads below 150 ft. operation of the pump and the turbine at the same speed will give optimum results.

—for heads over 150 ft. there is increase in the unit output and better overall efficiency if as a turbine it is operated at a lower speed than as a pump.

M/s Allis chalmers who have done extensive work in this field have supplied/are supplying quite a few installations.

(*a*) Two for Pedreira Plant in Brazil, Sao Paulo, each rated for 18,720 HP, at head of 89 ft. and 150 RPM for turbine operation. For pump operation the unit will deliver 1800 cfs against a dynamic head of 78 ft. with head ranging from 60-90 ft. The motor rating is 19,100 HP.

(*b*) The first reversible pump turbine was installed in America at the Flat-Iron power and pumping plant of the Big Thompson Project. This is used for pumped storage and not required for regulation of the load. There are no wicket gates or governor for the unit. When starting as a turbine the unit is synchronised by means of the butterfly valve.

A unique feature of the unit is that it will operate at 300 RPM while pumping and at 257 while generating.

The pumping head varies from 170 to 300 ft and for turbine operation the variation is between 290 and 140. Model tests for a 12000 HP for (turb) operation under a 290 ft head have shown :

For 257 RPM operation that the efficiency is consistently higher than for 300 RPM operation up to 260 feet and the horse power is higher than for 300 RPM operation up to 260 ft. head.

(*c*) The largest pump-turbine was built for the TVA. The unit is capable of generating 120,000 Hp at about 233 ft head and is rated for 80,000 Hp under 190 ft head. It can pump 4600 cusecs against 172 ft head and is rated for 3900 cusecs against 205 ft head. The speed is 105 for both the operations. The runner impeller is over 22 ft in diameter, which makes it the largest Francis runner in the world. The cost of the pump-turbine is 1,377,746 and motor generator 1,420,174.

(*d*) the New York State Authority is installing 12 pump turbines at Tuscarora Plant.

There are serious difficulties to be encountered when extending the range of operation of Kaplan turbines. From the hydraulic point of view lower specific speed is necessary. This requirement calls for shorter blade lengths. Mechanical enormous loads to be supported calls for large hub diameter to accommodate the large bearings. Tests have shown that narrow vanes decrease the efficiency.

The variations in the hub diameter/runner diameter with the head increase may be gauged from the following table (taken from Escher Wyss' booklet on Hydraulic Installations):

Ratio $\frac{\textit{Hub diameter}}{\textit{Runner diameter}}$	*Head in meters*
0.52	39
0.54	44
0.55	46
0.60	63
0.65	81

To circumvent these difficulties Deriaz of English Electric Company suggested reversion to a mixed flow arrangement—a Francis turbine with mobile blades. The axes of the runner vanes instead of being at right angles to the shaft axes are inclined to it. With this design this turbine can be used for heads upto 600 feet. This turbine can also be used as a pump. The first installation as a pump turbine was at Sir Adam Beak Station on Niagara.

When Hydro Ontario began consideration for installation of a pumped-storage plant development work at that time indicated that only 30,000Hp turbine and 3200 cusecs pump operating under a head of 80 feet can be obtained. A total pumping capacity of 30,000 cusecs was required by the Commission.

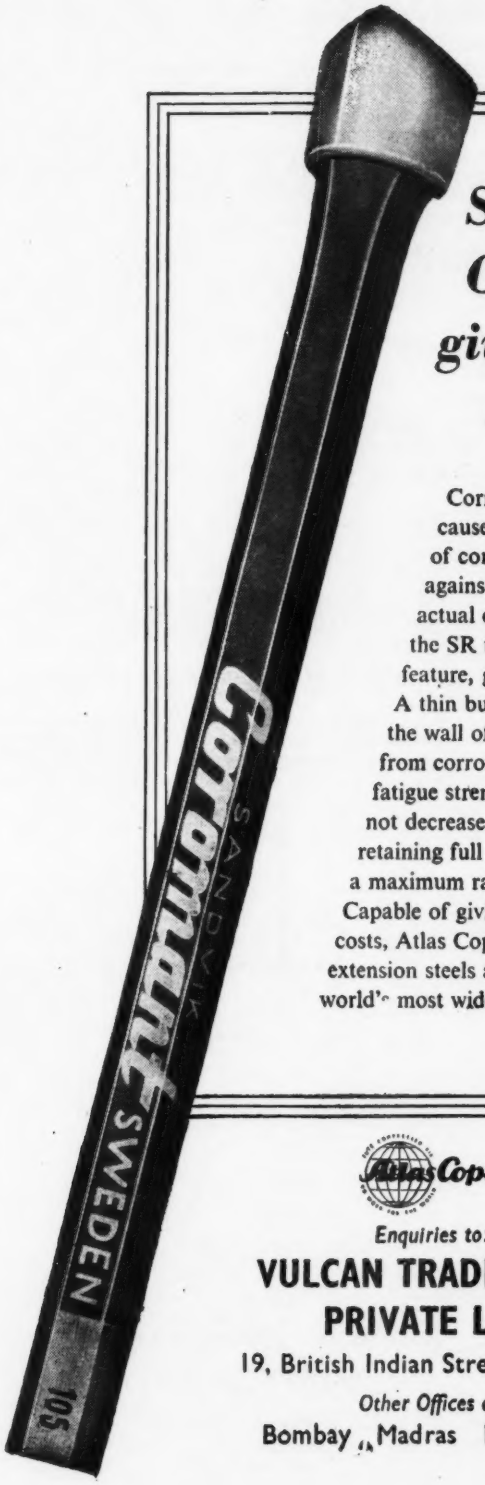
To meet these requirements Deriaz runners were selected. These are six pump turbines each pump will discharge 4000-5000 cusecs under a variable head 90-60 ft. respectively as turbine will 40,500 Hp under a head of 80 ft. The speed is 92.3 for both the operations.

The runner is with eight blades sloping 45 degrees from the hub. The blade angle can be adjusted from the servo motor located in the hub. The unit when acting as a pump is started with the blades in the closed position and brought to speed without the necessity of depressing the water level in the draft tube.

TUBULAR TURBINES

The under water power plant, Arno Fischer system, is a novel departure from the conventional arrangement. In an effort to reduce the construction costs in a rum-off-the-river plant German engineers had

[*Continued on page 29*



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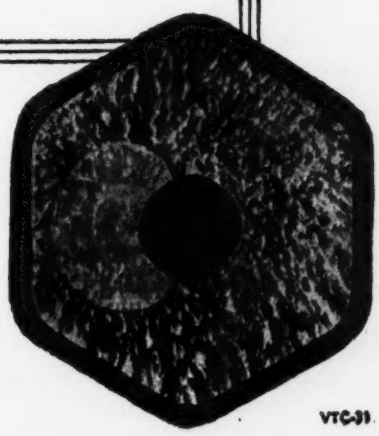

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Determination of Waterways in Bridges and Culverts

By K. V. KRISHNAMURTHY

The problem of undue affluxes at railway and road bridges and the necessity for increasing their waterways has been, for long, engaging the attention of flood control planners in India. Attention was given to this question by the Inter-Provincial Flood Conference between the States of Bengal, Bihar and U.P. as early as in 1939-40. With the establishment of a wide network of flood control organizations after the disastrous floods in 1954, this question again came into prominence and a number of Committees have been set up for the consideration of the problem by the various River Commissions. More recently, the problem became still more important with the appalling tragedy of the railway bridge collapses at Ariyalur on the Southern Railway and Mahboob Nagar on the Central Railway which culminated in the setting up of the All-India Committee of Engineers by the Ministry of Railways.

The Nature of the Problem

In this context it will be fruitful to record the essential nature of the problem. For large sized bridges, it will be possible to utilise the available techniques of storm analysis, unit hydrograph derivation, frequency study to fix a certain magnitude of maximum discharges for purposes of bridge design. For large watersheds, if data is not available, arrangements can be made for their collection, and these methods followed, if not immediately, at least later when more data becomes available. But, small culverts will continue to be constructed at innumerable places and it will not be possible to collect data for every one of the small sized crossings, as in the case of the large sized bridges. In these circumstances, paucity of essential data will continue to be a problem even in the remote future in the case of small culverts. To overcome this difficulty, it is desirable to conduct regional studies on the basis of available data, meagre as it is, which could yield design values for adoption with a reasonable degree of accuracy and safety at specific culvert sites that would remain ungauged even in the distant future.

Hydrologically, there is an essential difference between large areas and small watersheds. Flood peaks in large areas are very often the result of prolonged intense rainfall, whereas the flood producing precipitation in the case of small areas is usually of the cloud-burst type. Flood flows in large areas would show a tendency to maintain sustained peak values, whereas in the case of small areas, flows will be of the flash flood type. These differences make it necessary to collect and analyse the rainfall intensities of very short durations, sometimes of the order of minutes. In large areas, unit periods of 24 hours or even multiples thereof may, perhaps, suffice.

Moreover, the element of risk in a vexatious feature, associated with design discharge for culverts and bridges. If absolute immunity is required it will be imperative to design for the maximum possible flood which would occur very infrequently. Designing for values lower than the maximum possible flood would intrinsically carry with it the element of risk. It will be interesting to recall the I.R.C. specification concerning the determination of design maximum discharge for road bridges. The relevent extract reads as under.

"It may occasionally be found uneconomical to design a bridge for the absolute maximum discharge which may occur at very infrequent intervals. Before accepting, in the design, a discharge figure lower than the estimated absolute maximum, a careful examination of the flood frequency graphs should be made and the degree of risk involved in assuming a lower discharge estimated. Detailed reasons justifying the figure shall be recorded in each case".

If it is thus considered economical to design a bridge for a value less than the maximum possible discharge, the element of calculated risk is inevitably involved.

The Objectives

Stream gauging at every road or railway crossing being ruled out, recourse has necessarily to be made for deriving flood hydrographs and peaks from rainfall data.

In small areas, times of concentration being very small i.e. of the order of a few minutes or a few hours, rainfall intensities for short durations should be known for facilitating the choice of design rainfall values. Besides intensities and durations, the corresponding frequencies are also to be known. Therefore, rainfall intensities for short durations and known return periods should be determined for small culvert designs.

Brief Description of the Work done in the U.S.A.

US Weather Bureau

Studies on intensity frequency analysis for short durations like 5 to 240 minutes and return periods of 2,5 and 10 years have been done in the United States Weather Bureau in relation to the fixation of design criteria for airport drainages but are of great significance for the design of the waterways of the small culverts as well. The basic steps involved follow.[1]

(*a*) *Examination of data for undertaking frequency analysis*

For this purpose, the data of about 650 recording gauges and 1300 non-recording gauges was utilized.

[1] "Rainfall intensities for local drainage design in the United States". U. S. Weather Bureau Technical Paper No. 24, August, 1953, Rev. Feb., 1955.

For the recording gauges, data was available for a period of 10 years, 1940-1951. Some of the stations had longer data. At each station rainfall amounts equal to or above a selected certain base value were considered. The base value was so fixed that the number of clock hour amounts obtained would atleast equal the years of record for that station.

(*b*) *Frequency analysis of clock hour rainfall*

At each station the clock hour rainfall amounts were tabulated in descending order and the return period for each rainfall amount determined. A frequency curve was fitted to indicate the return period for any clock hour rainfall amount. The return period was computed by dividing the period of record by the serial number of the amount arranged in decreasing order. From the frequency curve, two year clock hour rainfall amounts were read off for all the stations (See Fig. 1)

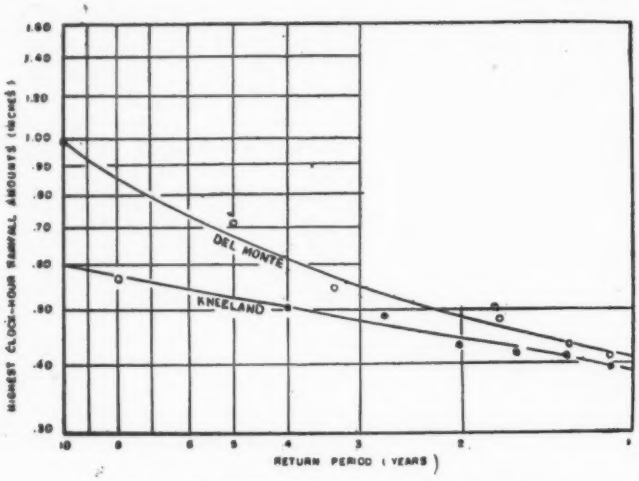


FIG. 1 FREQUENCY CURVES OF CLOCK— HOUR RAINFALL

SOURCE:- U. S. W.B.

(*c*) *Maximum hourly versus clock hour rainfall*

On the basis of available data, a relationship was obtained between maximum hourly precipitation and clock hour precipitation.

(*d*) *Derivation of 2 years 1 hour rainfall amounts*

Using the relation in the above step, 2 year clock hour rainfall amounts were converted into two year one hour rainfall amounts. Isolines were drawn for the area under study showing the values of 2 year 1 hour rainfall amounts (See Fig. 2)

(*e*) *2 year 1 hour rainfall versus 2 year 24 hours rainfall.*

In order to utilize the data of non-recording gauges, a relation was established between 2 year 1 hour and 2 year-24 hour rainfall data. The 2 year 1 hour rainfall data derived by applying this relationship to the non-recording gauge data was used for interpolation purposes in drawing the isolines of 2 year 1 hour rainfall values for the area under study (See Fig. 2)

(*f*) *One hour rainfall versus rainfall in other durations*

On the basis of the data of select stations, relationships were established between 1 hour rainfall intensity and that in 5,10,15,30,90,120,150 180 and 240 minutes at each station.

(*g*) *5 and 10 year rainfall to 2 year rainfall*

Again on the basis of the data of select stations, relationships were established between 5 year and 10 year-1 hour rainfall values and 2 year-1 hour rainfall values.

(*h*) *Intensity duration curves.*

The final step is the preparation of intensity duration curves (See Fig. 3) which would readily give the intensity for a frequency of 2,5 and 10 years and for a duration of 5 to 240 minutes.

The study can be extended if necessary, to yield 50 year intensities for other durations.

Studies done in the Central and Southern Florida Flood Control Project[2]

A similar analysis was done in the case of the Central and Southern Florida Flood Control Project.

In the project area, which is a flat country, the pattern of storms and short duration intensities were studied and procedures developed for use on a number of control structures with small drainage areas. A generalized rainfall-frequency study for the entire region of the Central and Southern Florida was required, as stream-flow data necessary to prepare flood-frequency curves was limited, or even non-existent in some cases. The generalized frequency study for short duration intensities was used to determine annual flood damage and benefits that would accrue from proposed flood control measures.

Annual maximum 1-day rainfall values were tabulated for about 120 stations while 2-, 10-and 30-day values were listed for 13 key stations in the area of the Central and Southern Florida Flood Control Project.

After tabulating observed annual-maximum rainfall values, the logarithms of observed values were obtained and the means and standard deviations were computed. Frequency curves were computed on the assumption that the logarithms were distributed normally. A test of goodness of fit was made by determining the number of observations exceeding the

[2] Rainfall frequency estimates, Central and Southern Florida Flood Control Project Part VI, Section 6.

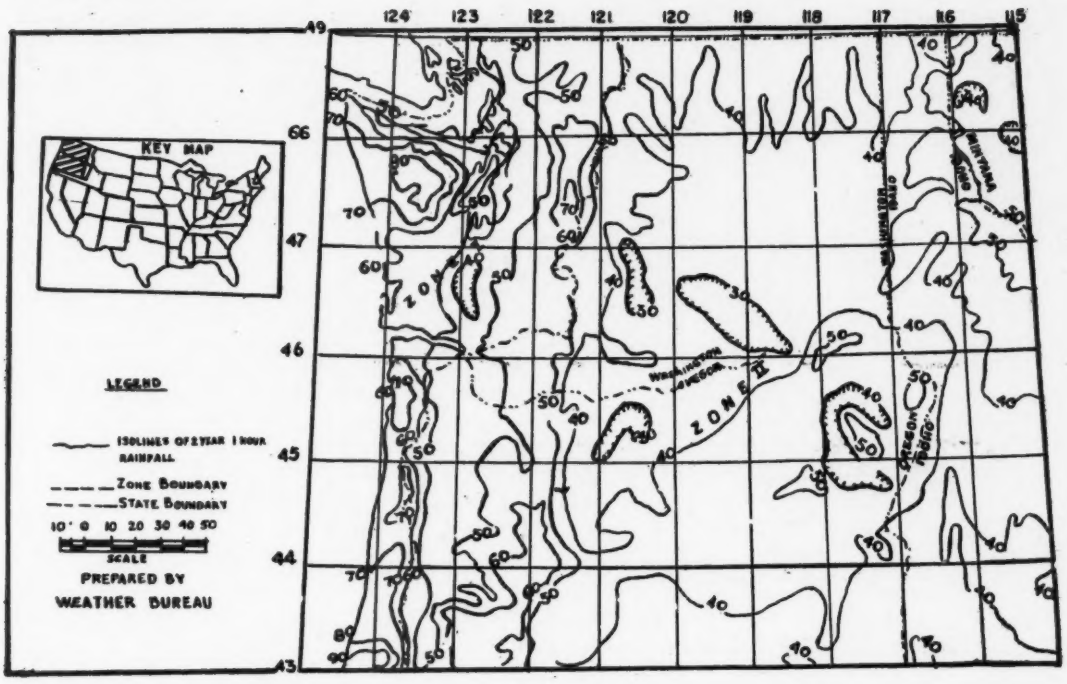


FIG. 2 ISOLINES OF 2 YEAR 1 HOUR RAINFALL
(FROM U.S.W.B. TECHNICAL PAPE NO 24.)

computed frequency curves and comparing this number with the number theoretically expected. A certain degree of skewness was found in the distribution, for which due allowance was made in the statistical procedures for the determination of the frequency values.

Among the factors affecting frequency curves the following important elements were examined (*a*) the accuracy of the observational data of rainfall (*b*) the effect of length of record, and (*c*) the goodness of fit.

Possible Analysis under Indian Conditions

The type of analysis as was done in the U.S. Weather Bureau is, however, not possible in the Indian conditions, where there is extreme shortage of self-recording rain gauge data. This paucity of data is now being sought to be remedied in times to come by a number of Departments in India. In the monsoon seasons of 1957 and 1958, the Railways collected some continuous rainfall data even without automatic instruments with the help of special staff posted for the purpose. In addition to this data with the Railways, there is some data with the India Meteorological Department. It is gathered that there are at present 71 self-recording rain gauge stations with five or more years of data. The extent of data available at these stations for analysis is shown below.

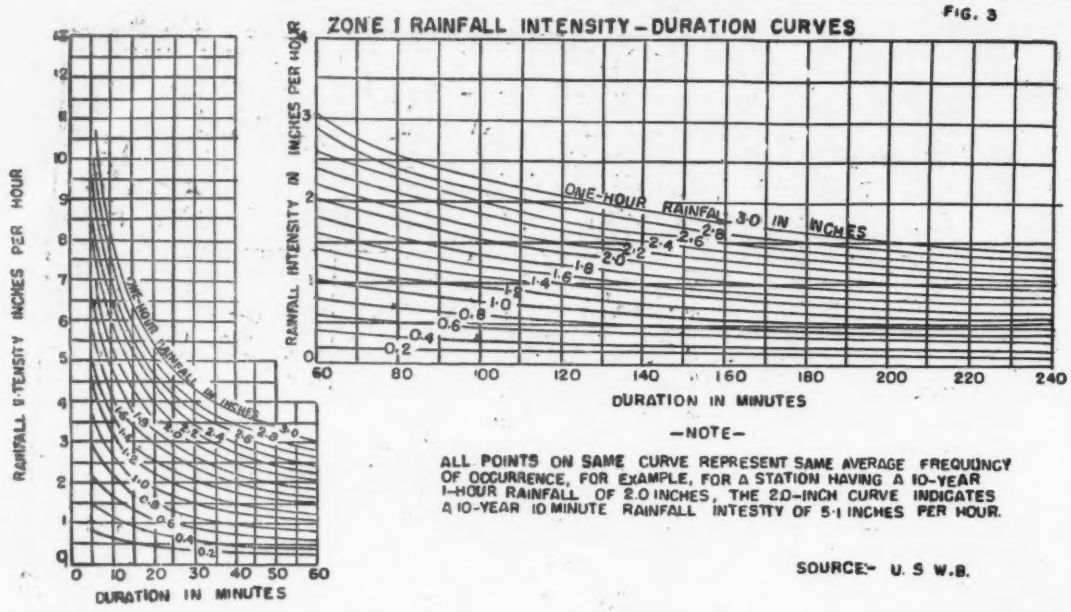
No. of station	*Period of data*
7	21—29 years.
9	11—20 years.
18	10 years.
28	5—9 years.
9	5 years and less.

All this data could be analysed in the manner described before to yield two-year one-hour rainfall intensities. Studies can be undertaken for the determination of suitable relationships between hourly intensities and intensities of multiples and sub-multiples of 60-minute periods. Such an analysis would make available a variety of data from which suitable design rainfall values can be chosen.

Design Rainfall Intensities

In the absence of detailed economic analysis, methods for the choice of design rainfall values for bridge and culvert waterway design continue to be arbitrary, as in our country, in the United States as well. The practice of the U.S. Bureau of Public Roads is to adopt a 50-year flood intensity for primary and interstate roads and 25-year flood intensity for secondary roads and feeders to the secondaries.

FIG. 3


ZONE 1 RAINFALL INTENSITY-DURATION CURVES
RAINFALL INTENSITY IN INCHES PER HOUR
ONE-HOUR RAINFALL 3.0 IN INCHES
DURATION IN MINUTES
RAINFALL INTENSITY INCHES PER HOUR
DURATION IN MINUTES
—NOTE—
ALL POINTS ON SAME CURVE REPRESENT SAME AVERAGE FREQUENCY OF OCCURRENCE, FOR EXAMPLE, FOR A STATION HAVING A 10-YEAR 1-HOUR RAINFALL OF 2.0 INCHES, THE 2.0-INCH CURVE INDICATES A 10-YEAR 10 MINUTE RAINFALL INTESITY OF 5.1 INCHES PER HOUR.
SOURCE- U. S W.B.

Rainfall-Runoff Relationships

The flood hydrograph for the design rainfall intensity and distribution pattern is to be derived by the unit hydrograph method. This method would be easy in the case of culverts where discharge data has been observed. In order, however, to overcome the problem of obtaining a rational rainfall run-off relationship at other crossings, where there are no flow observations, it is desirable to conduct unit hydrograph studies on a regionalised basis and evolve suitable synthetic, coefficients for hydrograph construction. The analysis corelating unit hydrograph characteristics with basin storm characteristics would provide the necessary criteria for construction a synthetic unit hydrograph with the help of which the flood hydrograph corresponding to the design rainfall value may be derived and adopted as the basis for the bridge or culvert waterway design.

In order, however, to simplify the corelations involved in this analysis, it is suggested that the following parameters can be taken in the first instance before analytical techniques can be refined. The unit hydrograph parameters could be (*i*) base width, (*ii*) lag time and (*iii*) the peak ordinate. The basin parameters could be (*i*) total area, (*ii*) length of the longest water course, (*iii*) length from the remotest point along the waterway to the centroid of the basin and (*iv*) stream slope.

Bridge and Culvert Hydraulics[3]

So far, only hydrological aspects involved in choosing the appropriate value for the maximum discharge in bridge or culvert design have been discussed herein. The nature of bridge pier obstructions to flood flow is a hydraulic problem which has a close relation to affluxes and resulting scours. Considerable experimental and research work has been carried out on the subject in the United States, as is embodied in the work of Dr. Yarnell.[4] On the basis of experimental observations conducted at the University of Iows, Dr. Yarnell developed methods for the calculation of upstream afflux and back water curve in corelation with the extent of channel contraction and the length and slope of the piers. The computation of backwater height upstream of a bridge or culvert for a given discharge and known conditions at the crossings is an a spect which should receive in India greater attention than hitherto in relation to this problem.

The Economic Aspect

In addition to the hydrologic and hydraulic aspects, there is an economic aspect of the problem as well. In considering this question, the issue has always come up as to what is the extent of afflux which should be considered as permissible. The following approach, which is essentially economic in content, would be of interest, in addition to the angles from which the question has usually been considered in India. Expressed in other words, the question may be put as: To what extent is it economically sound to increase the waterways? To increase it so much as to completely eliminate all afflux is no doubt possible, but economically is it worth while apart from the effect of such a widening on the hydraulics of flow at the crossings. The cost of widening the bridge for eliminating all afflux can be computed. On the other extreme, not

3 "Bridge Waterway Design" U.S. Bureau of Public Boads, Hydraulic Research Division, Jan. 1957, preliminary drafts, unpublished.

4 "Bridge Piers as Channel Obstructions" by Dr. D. L. Yarnell, U.S. Department of Agriculture, Technical, Bull. No. 442.

reducing the afflux at all would cost nothing but result in a certain amount of annual damage. By computing intermediate points and estimating the costs and benefits involved in preventing varying degrees of damage, a curve can be constructed, as in Fig. 4.

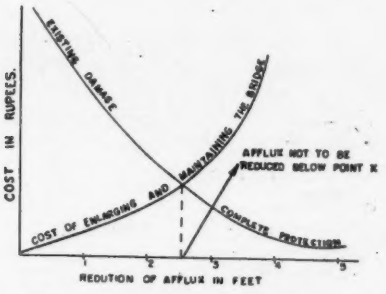


FIG 4. ECONOMICS OF WIDENING BRIDGE AND CULVERT WATERWAYS

Then, it is obviously uneconomical to widen the bridge and reduce the afflux below the point of inter-section; because the cost of widening and maintaining the widened bridge would be more than the damage prevented. This would indicate a possible reduction which is not uneconomic.

The question remains as to what is the limit of widening in the most economic manner. The answer to this can be found in the economic return that would accrue to the farmer as a result of affording protection which he does not now enjoy as a result of flood caused by excessive afflux. Construct a table showing the extent of the flood protection corresponding to different widenings and the return to the farmer as given below. Plot a curve showing the relation between the two which will be somewhat of the shape shown in Fig. 5.

Flood Protection	*Average Annual Return in Rupees per acre.*
100%	15
2 yr. flood	0
5 yr. flood	10
10 yr. flood	13.5
20 yr. flood	14.6
Complete protection i.e. 100%	15

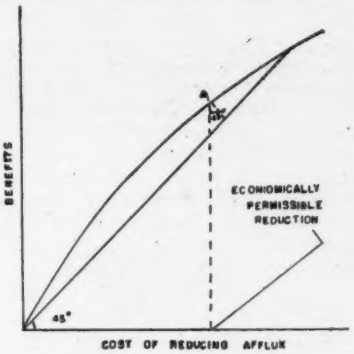


FIG. 5. ECONOMICS OF BRIDGE AND CULVERT WATERWAYS.

This economic approach to the problem would perhaps help us to find a convincing answer to the question of the extent of the permissible affiux.

It is, however, realised that the necessary economic data needed for the analysis is not readily available. But it appears desirable to make arrangements for the collection of this information with respect to some important road or railway bridges. This would enable us to undertake a solution of the problem, not only in respect of bridges for which the information will be collected but also may make it possible to develop some general relationships applicable to some areas with common conditions or, in the alternative, constitute enough precedent experience to undertake a solution of the problem on these lines.

Hydraulic Turbines—III

Continued from page 24]

advanced a design wherein the dam and the power house were combined. Arno Fisher using an Escher Wyss patent designed the Rostin Power station where the generator has been built on the hub or rather the extension to the hub, of a Kaplan turbine. The combination is located in the pier. The proposals of Arno Fisher have been viewed by Engineers unfavourably. "All agree, however, that political pressure, graft and favoritism played so large a part in the development of this innovation that it has, so far, probably resulted in more harm than good and represents a dark chapter in the history of German power engineering" (Bios Report).

The Rostin unit is still in service. The next stage was combined generator and turbine. The generator rotor was palced on the outside of the rigid blades of a propeller runner. Further continued research brought forth two more types.

In one design the generator is located in the draft tube. It, of course, warrants careful model tests to see that the foreign body in such a sensitive area would not have detrimental effects. The shape of the generator supporting ribs are to be decided after tests.

In the other design the generator is arranged in the inlet. Compared to a conventional Kaplan turbine the above two designs have shown definite improvement in efficiency of about 3 to 6% particularly in the full load condition.

The unit outputs have increased up to as high a value as 19,250Hp. For the Rance Tidal Project 38 tubular turbines are decided each producing 9000 kW at 88.2 RPM. The generator will be located in the inlet.

The growing interest of these units can be gauged by the number supplied by certain of the manufactures.

Between 1936 and 1951 Messrs Escher Wyss had supplied 75 units of different types. There have been further supplies—Messrs. Neyrpic have supplied over 12 units with Hp ranging from 69 to 19000. In England English Electric is installing 145 HP unit in Shin Weir.

Atomic Power for India

The following is a brief but authoritative statement on Atomic Power plans of India as presented by the Department of Atomic Energy :

India will require a substantial increase in electrical generating capacity to meet her fast developing economy and it is anticipated that against the present installed capacity of less than 6 million kilowatts, the requirements would, in about 25 years, reach a target of well over 50 million kilowatts. A survey of the potential power resources has been made and to conclusion is irresistable that a substantial portion of the energy requirements of the country will have to be met progressively from nuclear sources.

The total hydro-electric capacity in the country, including the difficult reaches of the Himalayas and in regions of low power demand, is of the order of 43 million kilowatts. Not more than half of this is likely to be exploited economically during the next 25 years. India's coal reserves too are also limited and concentrated in certain belts in the eastern parts of the country and with growing industrialisation there is little doubt that coal cannot meet in any large measure the electric power needs of the future. The oil resources are meagre and in any case the role of oil in the generation of power is limited.

India has to base its nuclear power programme ultimately on thorium which is available in abundance in the country. Consequently, the nuclear power programme will have to develop in three stages, the first stage being reactors fuelled by natural uranium producing plutonium as a useful by-product. The second stage would use plutonium either with uranium in fast breeder reactors to produce more plutonium or with thorium to produce uranium 233. This will lead on to the third stage reactors run on thorium, including in particular those working on the thorium-uranium 233 cycle. This is the stage we are aiming to reach so that cheap and abundant power can be obtained. The time interval in going through the first two stages of the fuel cycle to reach the third is necessarily long and a beginning has to be made as early as possible to ensure that nuclear power based on the abundantly available thorium can contribute its share to the energy requirements of the country. The Atomic Energy Commission has estimated that a start with an installed capacity of about 1 million kilowatts based on natural uranium can be made in the near future. This may well have to be increased in view of the future demands that would be made on nuclear power. The Atomic Energy Commission has examined in detail the most suitable regions where first stage reactors may be installed. Three regions have been found suitable from the economic point of view as these regions have fairly large electrical grids, heavy industrial potential and are yet far from coal-fields. These regios are :

(i) Western India
(ii) North-West India
(iii) Southern India

A region-wise study of the energy potential of the country shows that by 1986 about 10-15 million kilowatts of installed nuclear capacity would have to be provided made up of :

Western India	4.5 million kW
North West India	2.3 million kW
Southern India	2.3 million kW
Other parts of India	2.4 million kW
Total :	10-15 million kW

The Government of India have approved the construction of the first atomic power station to be located at Tarapore in Maharashtra in Western India between Bombay and Ahmedabad, so that power could be fed into both the Bombay and Gujerat regions. The original decision was to instal the station with one reactor of 250,000 kW. As there seem to be considerable operational advantages in providing this capacity with two reactors, it has now been proposed to set up a 300,000 kW station with two units of 150,000 kW each.

A project team was set up on 1st of August, 1959 under the leadership of Shri M. N. Chakravarti, a former member of the Railway Board. The selection of the site for the power station has engaged the attention of the project team and a systematic examination of the coast-line extending from Bombay to the Gulf of Cambay was carried out to determine a suitable location for the station. The major factors that had to be borne in mind in the choice of a suitable site were :

(1) Engineering requirements with particular reference to cooling and foundation conditions;
(2) Electrical considerations affecting the despatch of power generated to the load centres; and
(3) Health and safety considerations under all operating conditions of the station.

A number of coastal locations were considered, as sources of river water supply are inadequate in this region.

The Government are considering the establishment of two more nuclear power stations of 150 mW capacity capable of doubling later.

Irrigation in the Third Plan

For the present we shall not discuss the draft outline of the Third Five Year Plan as a whole presented before the country by the Planning Commission. We shall restrict ourselves here to commenting on a few points regarding the programme for irrigation suggested in the Plan.

It appears that in this Plan stress has been laid on the completion of the major valley projects that are already in hand. Very few new major projects have been proposed. That is, in our view, a right decision on the whole in the present context. For, what is of extreme importance today is to secure substantial increase in food production and in this respect minor and medium irrigation projects would help considerably. For one, these do not require large capital to be blocked for several years. For another, requirements of foreign exchange for smaller projects are very little, and finally these can be undertaken all over the country at short notice. The figures, however, on first glance suggest that nearly 60% of the total investment during the Third Plan is reserved for major projects leaving an inadequate amount for medium projects. But a better scrutiny is possible only when the breakdown figures are available. These should not, however, convey the impression that we are opposed to major projects. Rather, on the contrary, we believe that major projects are essential in the long run to meet our long term agricultural needs. But at the present phase of our development we are confronted with the task of meeting our food deficit within the shortest period of time. Therefore we feel that at this stage more funds should be allocated to medium and minor projects than has been done in the Third Plan, *in addition* to the major projects included in the Plan. This will mean increasing the total allocation for irrigation.

We do not understand why such an important project as the Farakka Barage on the Ganga does not seem to be included in the Plan even after repeated assurances in the Parliament. This project obtains its high priority not from the point of view of irrigation but from that of the flushing of the Bhagirath which would then assure a less troublesome operation of the irreplaceable Calcutta Port.

The Draft Outline mentions that a total of about 450 million acre feet of water can be available for irrigation from the Indian rivers. But it is not clear from this whether sufficient margin has been kept for flushing the lower reaches of the rivers after the construction of dams. Also the need for a minimum depth of water for inland navigation both on the main river channels as well as on the main canals has to be assured before estimating the total quantity of water that may be available from the Indian rivers for irrigation purposes. We raise this point because the experience of valley projects in our country is new. Whatever experience has been gained in other countries leads us to the conclusion that our enthusiasm in building high dams should be tempered with the wisdom of maintaining the health of the rivers in the lower reaches. This lesson is particularly applicable to our country because the rivers originating from the Himalayas are prone to heavy siltation. This complicates the problem of our valley development from which other parts of the world like the Deccan region in our country or the Rocky Mountains region in the States are comparatively free.

We are glad to note that while planning for irrigation the Commission has taken due note of the problem of drainage and water-logging. These two aspects were extremely important and needed urgent consideration. For, what we are gaining by way of irrigation should not be lost even partly through the effect of these problems. We had opportunities of stressing the need for afforestation and soil conservation from time to time through these columns. From this point of view we find that while the last two Plans had seriously neglected these programmes, the present Draft Plan does not seem to go far enough either. The problem of maintaining a substantial length of life for the reservoirs created by such large blocks of long term investment of capital by the nation is a major one. It is gratifing to know that the Draft has taken note of this problem but while making allocations for these items the planners do not seem to be bold enough. They admit that even the meagre targets fixed for the second Plan would not be fully achieved. While the third Plan has doubled this target, the problem needed a much larger canvas of operation. At least one million acres should have been proposed for afforestation of catchment areas of rivers, if not more. Such a programme is not only beneficial from the long term point of view but it also helps to meet the problem of unemployment.

It is good to note that the Commission stresses the need for investigation and research of river valley projects. This is a continuing programme requiring a great deal of thoroughness irrespective of the fact as to whether a particular project will be considered for execution early or not. We hope that substantial amount of funds will be set apart by each State and a separate machinery would be maintained to do a thorough job of it. The example of the Beas Project

investigation would indicate how such an extensive planning at an early stage gives a much better view of the total task.

The Commission has squarely admitted that "the irrigation systems are at present working at a loss in almost all States". This is indeed a serious state of affairs. Not that in our view these major projects would begin to give profit at the initial stages. But we do think that while in the past these projects were considered essentially and in the main as financial schemes, today that attitude and discipline has considerably weakened. With the advent of independence and popular democracy there is a race for regional development and allocation of funds in them. The ideas of welfare state and planning have further strengthened these tendencies towards long-term development investments in a hurry. Thus the eye on financial returns has lost its focus considerably.

Not that indirect benefits should not also be factors in our selection criteria. But as these developments have to go on for decades together in the future, it is necessary that the minimum return form these projects are secured in reasonable time, so that these again may be re-invested elsewhere. And this comes to mean that irrigation must be considered as an industry. Only then the necessary discipline and imaginative operation will emerge. We strongly advocate this line of thought which the planners have put forward in several cautious bits. One of the corollaries of the idea is that land reform programmes have also to be viewed from the same angle. In other words, it is not only the criteria of social equity but also of increased productivity that must be given equal weight, and it is our conviction that if the local legislators and the people are taken into confidence even as the individual projects are planned, they will understand and a consensus of opinion will emerge which will help considerably in operating these principles subsequently,

Thus on the income side from irrigation projects there is every justification for collection of enhanced rates for water charges and betterment levies from the cultivators if the "irrigation industry" is not to face a financial ruin. The analogy on this score with other major industries would not at all be unjustifiable. The rate of increase of income due to irrigation in money value that the cultivator receives today compared to what he used to get before the war is many times more than the rate of increase in water charges or betterment levies during this period.

Many projects can become financially more sound in addition to their irrigation aspects if the generation of power is also included (or increased, if already included) in the same. This is necessary for several reasons. Thus the imbalance that is now noticeable in this respect in some projects should be corrected as far as possible.

The problem of utilisation of irrigation waters made available by the completion of major projects had been worrying the Government all these years. It was, therefore, but meet and proper that the Commission has laid considerable stress on the various steps that have to be taken in this regard. In the specific field of irrigation the task of synchronisation of the various aspects of construction right from the head works to the cultivators' fields has been well formulated. But then the problem was not only to formulate the task as also to organise its effective execution. Here while we welcome the various suggestions including those on the problem of co-ordination between various State and non-official agencies, we would like the authorities to concentrate on finding out the best way in which *rural leadership grows both at local and on a regional level.* The multifarious tasks specified by the Commission cannot be performed by mere governmental machinery, howsoever far-flung and elaborate they may be. Rather, the more elaborate they are, the more difficult if becomes to get actual results at the base. This has also been the experience of Community Development as evaluated by several dispassionate study groups. The task has to be undertaken by the local rural leadership and the Government agencies should come in only as helpers. A degree of trial and error is of course implied in this process but there is no other short cut.

It has been the experience all these years that in the collection of water rates or betterment levy there has been quite a wide disparity between what is projected as necessary and what is actually achieved. Part of the responsibility in this respect rests on the risks of democracy. But while one can be tactful in this respect in the short run, the problem cannot be postponed forever.

The farmer who needs irrigation waters and who is benefitted mainfolds by it financially would not mind sharing in this benefit with the Government provided the whole matter is fully explained to him. Unfortunately this process of explanation has not been adequately performed by those whose task it was to do so. On the contrary, some of the politicians have found this issue as a pretext for mischief. There is no point in accepting the Plan on the whole by a party and then not undertaking the responsibility implied by such an acceptance. We believe that if the pros and cons of the financial aspects of the irriation projects are explained patiently and fully to the farmer in a systematic manner, the climate for undertaking his quota of responsibility could be created. The engineer and the administrator can be helpful in this matter in many ways, but for this the major responsibility lies squarely on the uneasy shoulders of the politician who craves to have more and more power to have the final say in everything but is reluctant to educate the public constructively when it implies sharing of the burdens of construction.

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International Conference on Information Processing

Social and Economic Repercussions of the Employment of Electronic Computers

While the principal effect of the 19th-century industrial revolution was to substitute machine power for muscular exertion by men or animals, the second, 20th-century, revolution is directed to relieving man of another type of drudgery—that represented by the lower kinds of mental work. Yet the introduction of thermal and electrical energy still left to a skilled worker the running of the machines which had replaced muscle power. And the expansion of industry, involving the development of ever larger managerial, administrative and distribution organs, caused a rapid growth in the number of white-collar workers performing tasks which, while mental, do not as a rule call for the use of the higher powers of the mind. What we are now witnessing is the progressive replacement of this labour force of skilled operatives and office workers by automatic mechanisms, and it is thanks to this further substitution of machines for men that we can look forward to another tremendous burst of technical achievement.

Symbolically, this process can be deemed to have begun with the introduction of Watt's centrifugal governor whereby a mechanical device, an information processing machine, replaced fractional throttle control, constant gauge-reading and manual dexterity. Since then the use of similar governor mechanisms has spread to many sectors of industry and transportation; examples that come immediately to mind are generating stations and rolling mills, where the machinery runs almost untended and decisions by men are only called for on particular occasions.

As industrial production developed, industrial management became an increasingly cumbersome and exacting affair. It became apparent that the decrease in the man-hours expended on the production of a manufactured article must be accompanied by an increase in the man-hours expended on administrative work, management, accounting and staff welfare, and that in many cases the increase made was not large enough, with the result that the business became "bogged down" through under-administration. In reality this difficulty merely reveals a structural imbalance: the automation of production, with consequent expansion, would seem to call for some mechanization on the management side, and this is as yet only at its beginning. For the moment, there is still a tendency for administrative staff to swell, entailing, incidentally, a number of serious drawbacks; without dwelling on the dangers of the completely non-mechanized office organization, instances which can be given are slowness in reaching decisions, the need for a multiplicity of checks (man being naturally prone to error), and the stresses caused by the interplay of ambitions and personalities found in every collection of human beings.

The advances of electronics having made possible the substitution of machines for men, the mechanization of the two sides can be brought back into balance and the hypertrophy of the office side checked by speeding up office operations and reducing the chances of error. Apart from this, fresh avenues are opened up to science by the possibility of resolving sets of equations with several variables at high speed—calculation of the movements of the heavenly bodies, exact meteorological calculations etc. Thus what is now being done amounts to the launching of a whole new industry, with unorganized information as its raw material and processed, directly usable, information as its manufactured product. Research and development work are proceeding at every stage of this transformation.

The utilization of electronic machines for information processing raises mathematical and technical problems of extreme interest and novelty, on which large numbers of researchers are engaged. It was for this reason that Unesco welcomed a proposal from the Joint Computer Committee (an American body comprising three associations: Institute of Radio Engineers, Association for Computing Machinery, American Institute of Electrical Engineers) for the convening of an international scientific conference on the subject.

Some hundreds of papers were submitted. But the Conference, held in June 1959 at Unesco House and attended by some 2,000 experts from all over the world, discussed no more than 66 which had been selected with the greatest care by a working party of experts from the countries most advanced in the field. These papers are being reproduced in full in the Proceedings of the Conference, which thus contains only documents of high quality relating to the main themes of the Conference. These were :

—Mathematical methods of numerical computation.

—Logical structure of digital computers.

—A common symbolic language for digital computers.

—Machine translation of languages.

—Structure recognition and adaptability of computers.

—Future techniques.

The Proceedings also includes a summary of the discussions which followed the reading of the papers and a summary of the expositions delivered at 13 special symposia

held concurrently with the Conference. The themes of the symposia were:

—High capacity and high performance memories, and problems of information selection.

—Algebra of commutation.

—Relation of digital to analogue computation.

—Logical organization of small computers.

—Linear programming.

—Detection and correction of errors.

—Information assembly, storage and search.

—Machine translation.

—Automatic programming.

—Numerical analysis on automatic computers.

—Logical organization of high speed computers.

—Methods of resolution of linear systems.

—Special programming techniques.

The book has recently been published and will be available with M/s Orient Longmans Private Ltd. 17, Chittaranjan Avenue Calcutta-13.

Professor P. AUGER
Secretary General of the Conference

British Automatic Concrete Tile-Making Plant

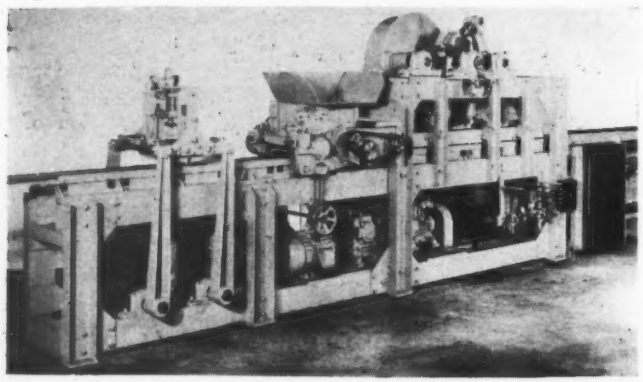
A double action tile making machine which will be one of the machines supplied by Tile Development Ltd., to Jaywoth Permaroof Inc., for their new factory near San Francisco. The guards have been removed to show the mechanism in detail.

The machine will produce any standard type of tile from the 15″×9″ (38,1 cms×22,9 cms) Marseilles pattern to the large "Double Roman" or the "Californian Shake" (a flat tile designed for low pitch roofs).

A production speed of up to 60 tiles per minute or 3,600 tiles per hour can be achieved. The machine is fully automatic and can be arranged to feed the pallets continuously without any pause, or alternatively with a pause of approximately 1/6th of a second at the moment when the knife descends on to the concrete to cut the tiles into the required lengths.

Further information from: Adams Powel Equipment Ltd. Team Valley, Gateshead, 11, England.

Br. Automatic Concrete Tile-Making Plant



UNITED NATIONS SPECIAL FUND : AID FOR INDIA

On 28th May the Governing Council of the United Nations Special Fund meeting at the United Nations Headquarters approved a grant of about $23 million towards financing 30 economic projects in 24 countries. Among the projects indicated special importance is attached to a grant to assist survey of potential Hydro-Power Sites in India.

The project for the survey of potential hydro-power sites in India is intended to carry out detailed surveys that will result in the final selection of sites for the construction of dams primarily for power production and also for irrigation and river valley developments. The UN Special Fund will contribute $2.36 million, while the Government of India will contribute approximately $5 million as counterpart funds.

On the basis of available topographic and hydrologic data, 64 sites have been selected on a preliminary basis with a total estimated potential capacity of 12 million kW. The proposed survey will be conducted through the Central Water Power Commission and Indian technical personnel.

The detailed investigations will include: aerial surveys for preparing large-scale maps of the reservoir areas with the assistance of aerial photography; ground topographic surveys for detailed contouring and mapping of work sites and project areas; geological surveys to explore geological conditions for proposed dams, power houses and other heavy structures; hydrological surveys to obtain flow characteristics of streams and of basins to design reservoir and spillway capacities; commanded area surveys and siltation surveys.

The Special Fund contribution, through the executing agency of the United Nations, will be towards the cost of the equipment for the soils and materials testing laboratory to be set up in Delhi and of field equipment for the

surveys comprising, in particular, 48 light drills. The Government of India's counterpart contribution will comprise the cost of operating and maintaining the equipment provided by the Fund, buildings for the laboratory and field stations.

The duration of the project would be three years.

It may be recalled that the possibility of such assistance from the United Nations Special Fund was visualised at the deliberations of the meeting of the Electric Power Sub-Committee of the Economic Commission for Asia and the Far East held in Tokyo in September, 1959.

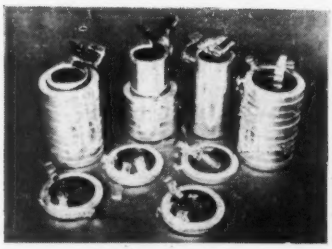
Indian Railway Contract for BICC Group

A further contract for the supply and installation of overhead equipment for 25kV 50 cycles A. C. railway electrification has been awarded to the BICC Group by the Indian Railway Board. This job is valued at £1,200,000 and covers some 300 track miles of the Eastern Railways system. The route to be equipped is on the main line from Delhi to Calcutta and lies between Gaya and Moghalsarai. It forms part of the second phase of the Indian Railway Board's electrification programme and is to be ready for use by July 1961.

The equipment will be similar to that at present being installed by the BICC Group for the South Eastern Railway, the order for which was announced in December 1958. Such rapid progress was made on that scheme that it was possible for a section of the line to be energised only 12 months later so that an electric locomotive could make a demonstration run for delegates attending a meeting of the International Railway Congress Association.

Prototype Coils in Aluminium Foil

Prototype coils in Aluminium foil for 50 kVA 11,000/488 Volt 3 phase oil-immersed distribution transformer developed by Northern Aluminium Company using Alcan aluminium fit on a standard 50 kVA iron core and have a total weight of 69 lbs. Their cost is estimated to be about half that of conventional coils.



Aluminium foil and strip for transformer windings are readily available in various other widths and gauges, and coils would with them have a very high space factor and excellent cooling characteristics. Further information on aluminium in all electrical applications is available from Alcan Asia Limited, P.O. Box 2121, Hong Kong.

New Indian Standards

Galvanized Steel Wires

The Indian Standards Institution has prepared the following five draft Indian Standard Specifications.

(*a*) Galvanized Steel Barbed Wire for Fencing [Doc: EDC 32 (486)] (Draft Revision of IS: 278-1951);

(*b*) Galvanized Steel Wire, Chain Link Fencing [Doc: EDC 32(519)];

(*c*) Standard Galvanized Steel Wire for Fencing [Doc: EDC 32(820)];

(*d*) Galvanized Stay Strand for Telegraph and Telephone Purposes, Singnal Posts and Suspension Strand [Doc: EDC 32 (521)]; and

(*e*) Galvanized Steel Wire Strand for Signalling Purposes [Doc: EDC 32(522)].

The first, namely Doc: EDC 32 (486) contains the draft revision of IS: 278-1951 Specification for Galvanized Steel Barbed Wire for Fencing (*Tentative*). The main modifications made in this revision are :

(*a*) basing the sizes of wire on metric system.

(*b*) increasing the minimum length of barbs, and

(*c*) provision of coiling on metallic or wooden reels.

All the five drafts, mentioned above, relate to a series of Indian Standards for Galvanized steel wires used for different purposes.

These draft standards will be circulated shortly to interested producers, users and technologists for eliciting technical comments. The comments will be taken consideration before the draft standards are finalized.

Horizontal Centrifugal Pumps

The object of IS: 1520-1960 Specification for Horizontal Centrifugal Pumps for Clear, Cold, Fresh Water published recently by ISI is to provide guidance to both manufacturers and users of horizontal centrifugal pumps for clear, cold, fresh water. The specification covers only the miniumum essential details for good quality horizontal centrifugal pumps.

The standard is divided into three sections. The first section covers terminology, nomenclature, standard units, classes and types, direction of rotation, accessories, and suction limitations of the pumps. The second section gives details of information to be supplied by the purchaser. The third section, besides detailing

[*Continued on page 36*

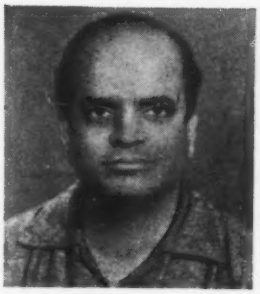
Our Contributors

Mr. Maung Aye, B. Sc. (Hons), B. Sc. (Tech), A.M.I.C.E., A.M.W.E., M.A.S.C.E., is Chief Engineer, Hydro-electric Department in the Electricity Supply Board, Burma.

Mr. K. S. Misra after studying in the Allahabad University received Technical Education in Thomason College of Civil Engineering, Roorkee. He served in the Irrigation Department of Bhawalpur (Punjab) and latter joined the Staff of Roorkee College of Engineering. Thereafter he worked in Orissa State on Mahanadi Delta Irrigation Scheme (Hirakud Dam Project). At present he is serving in the C.W. & P.C., (Ministry of Irrigation and Power, Govt. of India) as Superintending Engineer.

The present contribution is based on the Tour Report submitted to the ECAFE. Mr. Misra was one of the delegates of the Ecafe Team which went on a study tour of USSR and Hungary. He represented the Ministry of Irrigation and Power and Ministry of Transport and Communications Government of India.

Mr. N. Venkata Row. This concludes the series of articles on Hydraulic Turbines by Mr. Row who is with Messrs. Larsen & Toubro Limited, posted at Delhi.



Mr. K. V. Krishnamurthy is intimately connected with the flood control activities in the country, being the Deputy Director in chage of Flood Control Co-ordination in the Central Water & Power Commission; has been associated with the hydrological aspects of some of the major river valley and flood control projects in the country for the last ten years; was the leader of a six-member study team which was sent by the Govt. of India to the United States in 1956-57 for a study of the flood control problems, procedures and practices in that country; on return worked on the staff of the High Level Committee on Floods set up by the Govt. of India; a specialist in hydrology, irrigation and flood control and author of several technical papers on these subjects.

Mr. A. G. Mirajgaokar graduated in 1951 from Osmania University and received his M. E. from the University of Roorkee in 1957. A. M. I. E. and M.I. A. H. R. He is working as lecturer in Civil Engineering at Roorkee; at present in the United States under T. C. M. Scholarship programme for higher studies in Irrigation and Drainage Engineering. His last Contribution in our journal appeared in Vol. 9. No. 12.

[*Continued from page 35*

Technical Notes & News

information to be furnished by the supplier, covers pump tests, guarantees, tolerances and general requirements.

The specification is not intended to be restrictive in character and, subject to agreement between the purchaser and the supplier, some of the requirements of this specification may be either modified or made more elaborate.

The standard published in English is priced at Rs. 6.00.

Crane Weighing Machines

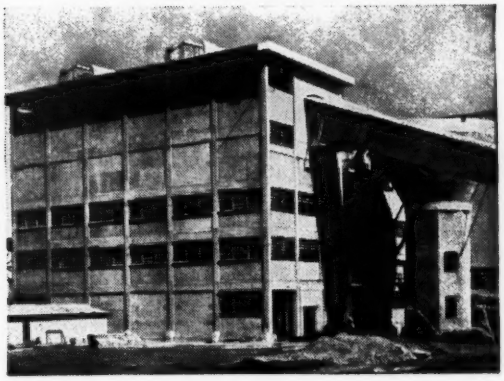
The Indian Standard Specification for Crane Weighing Machines (IS:1438-1960) published recently by ISI belongs to a series of Indian Standards on commercial weighing instruments being prepared at the instance of the Standing Metric Committee, Government of India, in connection with the introduction of metric system of weights and measures in the country. The other standards published in the series cover the general requirements for weighing instruments, and specifications for beam scales, counter machines, platform weighing machines, weigh-bridges, automatic weighing machines and steel yards.

In determing the limits for sensitiveness and greatest error, due consideration was given to the views of manufacturers and testing organizations, prevalent rules and regulations pertaining to weights and measures in India and the practices current in several metric countries. It is to be pointed out that the values for sensitiveness and greatest error specified in this standard are for new machines only.

The standard published in English is priced at Rs. 1.50.

Copies are available from the office of the Indian Standards Institution, 'Manak Bhavan', 9, Mathura Road, New Delhi-1, and from its Branch Offices located at Bombay, Calcutta and Madras.

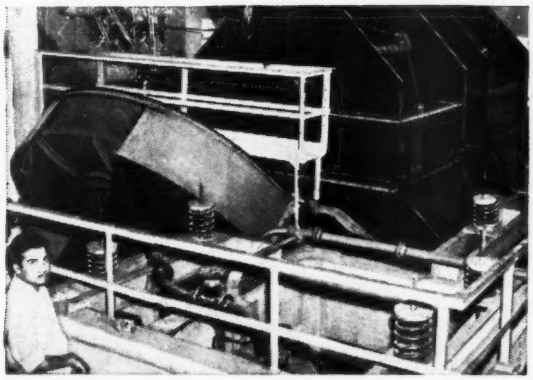
COAL WASHING CONSERVES INDIA'S COAL RESOURCES

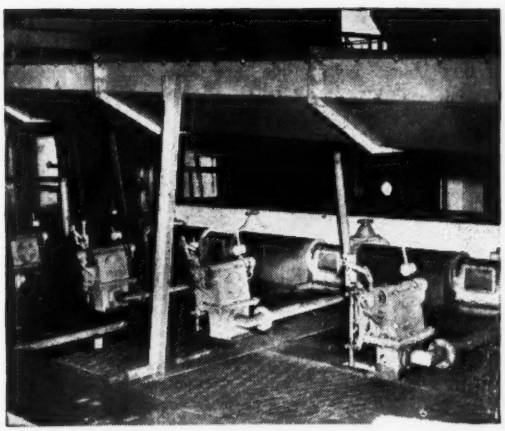


The coal washery illustrated here, a unique feature of the Durgapur Steelworks, was designed and erected by Simon-Carves.

The washery is a part of the coal preparation plant which washes, blends and delivers 360 tons of 3"—0 raw coal per hour. The washery is the first in India to use Drewboy dense medium separator, a device widely used in a number of coal washeries in the United Kingdom and Europe. The ½" — 0 fraction of the coal is treated in an ACCO feldspar jig washer, while stocking, blending and reclaiming are carried out on the Robins Messiter system.

The Simon-Carves coal preparation plant at Durgapur is helping India to upgrade inferior coal and use it for metallurgical purposes—conserving India's rapidly dwindling high-grade coal resources—helping to get uniform quality coke for the finest iron and steel.





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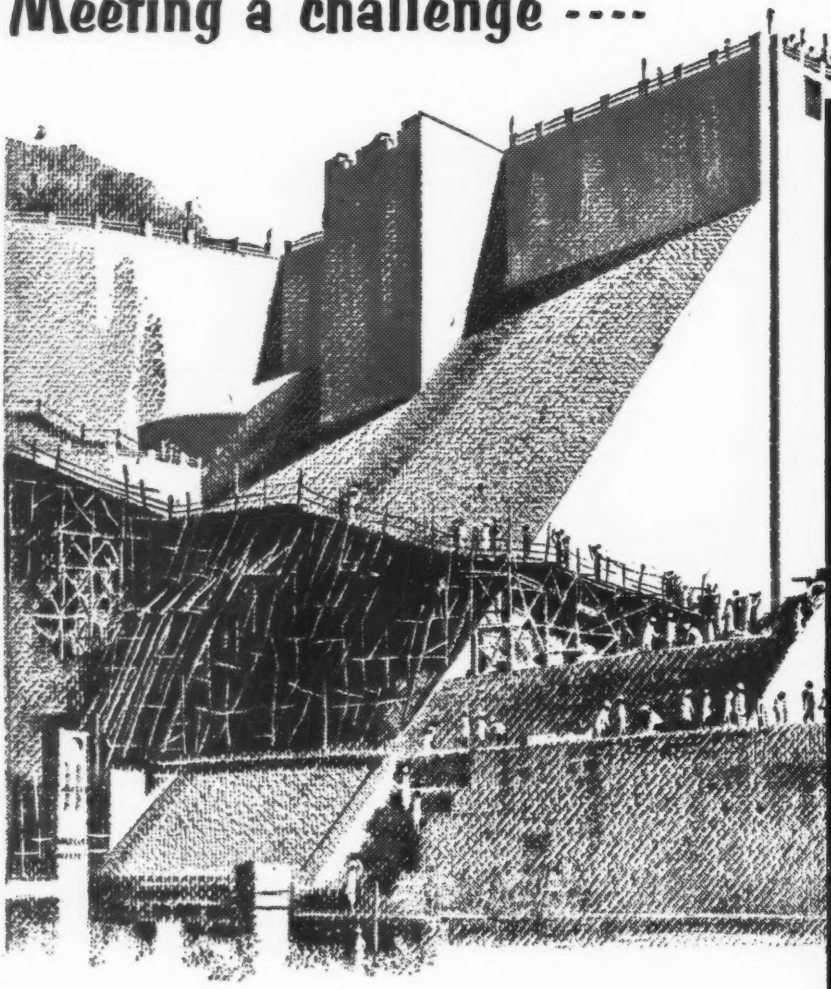
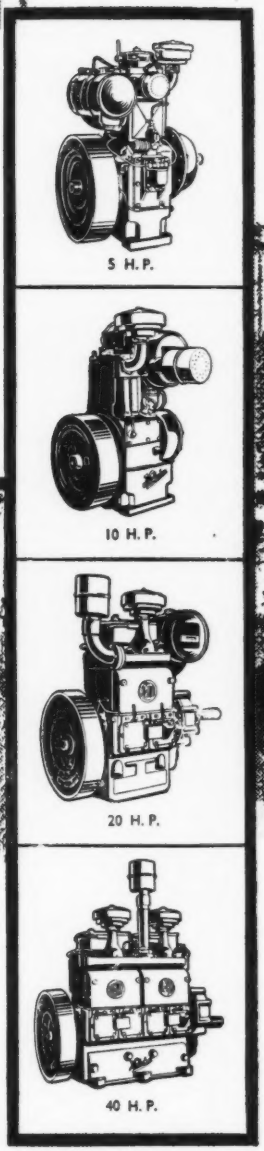
Meeting a challenge ----





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